केन्द्रीय भूमि जल बोर्ड

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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

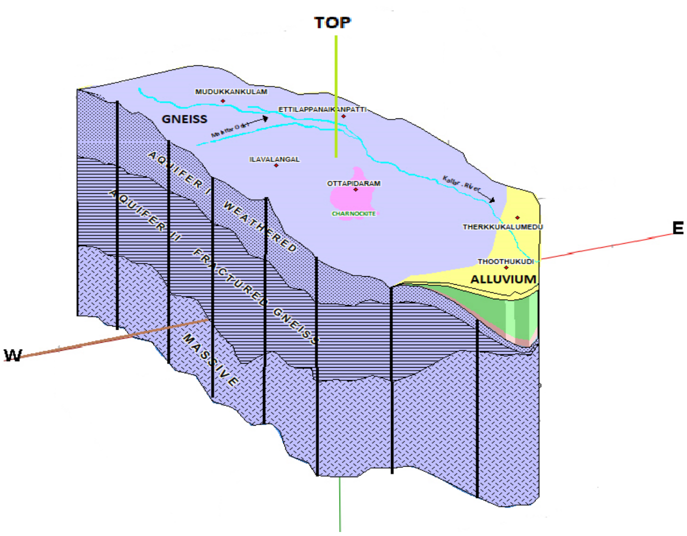
for Kallar Aquifer System
Tamil Nadu

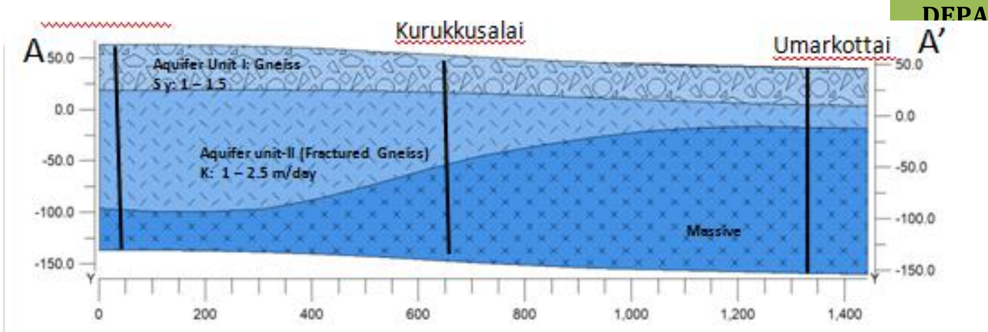
दक्षिण पूर्वी तटीय क्षेत्र, चेन्नई

South Eastern Coastal Region, Chennai

सरकारीउपयोगकेलिए

REPORT ON
AQUIFER MAPPING AND AQUIFER MANAGEMENTPLAN FOR THE KALLAR AQUIFER SYSTEM,TAMIL NADU





GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES
...ER DEVELOPMENT AND GANGA
REJUVENATION
...TRAL GROUND WATER BOARD
...TH 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 Madhya Pradesh.

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 Kallar aquifer system covering an area of 1691 sq.km occupying 33% of Thoothukudy district. This aquifer system covers 19 firkas of which Parivalikottaifirka falls under critical category calling for management interventions to work out long term sustainable grundwater resources. 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 in the Kallar 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 Kallar aquifer system.

(Dr A Asokan)

Regonal Director

EXECUTIVE SUMMARY

Detailed hydrogeological studies were conducted pertaining to the Kallar Aquifer system through an integrated approach involving data assemblage of geology, geophysics, hydrology and hydrochemistrywhich wereanalysed, interpreted and formulated management plans which formed the key elements of this report. The report is a documentation of the aquifer disposition, whereinthe lateral and vertical extent of the aquifers are brought out, also the aquifer properties of the study area are discerned through systematic studies which are considered to be the gauges in quantifying the resources. 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 Kallar aquifer system covering an area of 1691 sq. km falls entirely in Thoothukudy district occupying 33% of area**.** Thestudy area experiences semi-arid climate with 656 mm average rainfall which is lower than the state average of 965 mm. The low rainfall is an indicator to the constraints in proposing management plans. The major tributaries of Kallar river are*Othanatham, Chakarakudi, Kilachakarakudi and Perurani*. Thothukudy is the corporation and the major town in the Kallar aquifer system.

Kallar Aquifer system area is divided into the hard rock and sedimentary region. The hard rock region occupies almost 85% of the basin area comprising predominantly of Gneisses with patchy occurrence of Charnockites. The south eastern portion of the basin is flanked by the sedimentaries anchored on a Precambrian basement. The sedimentaries mainly comprise of the alluvium (coastal) grading down to the Cuddalore and the createaceous sandstone on the Precambrian basement.

The hard rock aquifer system is further subdivided into two units -The weathered zone at the top followed by a discrete anisotropic fractured/fissured zone at the bottom

The sedimentaries: Quaternary sediments are found in the southeastern part of Kallar aquifer system all along the coast and river courses. Coastal alluviums are underlain by Cuddalore formation of Mio-Pliocene age. This is followed by cretaceous sandstone with intervening clay layers. The maximum depth of the sedimentary sequence is around 65 m bgl with the alluviumextending to a depth of 20 m below which the underlying sandstone layers occur in varying depths ranging from 10 – 60 mbgl.The marine deposits extend all along the coast of Thoothukudy district. Aeolian sands are also found inisolated pockets in the coastal areas

The predominant water levels are in the range of 2 to 25 m bgl during pre-monsoon season and 0 to 10 mbgl during post-monsoon season of 2019. The net annual groundwater availability is 162 MCM and the gross groundwater draft is 62MCM and the stage of groundwater development is of 38% for the basin.

The major issues in the region are overexploitation and declining groundwater levels, massive crystalline formation and in-situ salinity and threat of Sea water intrusion along the coast and reported groundwater Pollution from industraial effluents.

In hard rock regions aquifer systemsthe 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 with transmissivity varying between 3 and 18m^2/day and specific yield of 1 – 1.5%. The fractured zone is fractured gneiss or Charnockite andthe yield varies from 0.5 to 11 lps and the transmissivity of this zone varies between 1 and 53 m^2/day and storativity varies from 0.00002 to 0.00001. In alluvial regions the first aquifer unit comprising of sand, clayey sand has thickness ranging from 10 to 55 m with yields ranging from 1 to 10lps and transmissivity values ranging from 245 to 770 m^2/day. The Tertiaries and the Upper Cretaceous formations underlie the alluvial formation and have yields ranging from 3 to 10 lps with transmissivity values ranging from 138 to 770 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 108MCM. The annual uncommitted runoff is 45 MCM and 60 % 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 13 MCM. 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 31 check dams, 49 Nala bunds and 94 recharge shafts are proposed in the groundwater stressed firkas of the basin. A total number of 235 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 13 MCM. The expected outcomes of these interventions are to mitigate declining groundwater levels, increase the pumping hours and most importantly increasing the sustainability of groundwater resources.

Complementary demand side management interventions are proposed for the desired benefits through peoples participation. A change in conventional irrigation practices to a water efficient technique is proposed to level down the counterbenefits of excess development.

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 KALLAR 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 Kallar 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. Heavy dependence on groundwater, years of deficient rains and disporportinate demand for waterdue to rapid populationn increase, urbanization and industrialization have put considerable stress on water management. 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 **KallarAquiferSystem**whichfalls in one of the major river basins in Tamil Nadu, and is that portion of Thoothukudy district lying within NorthLatitude8°41’00”–9°10’30”,EastLongitude77°48’00”–78°15’00”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 Kallar 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 Kallar 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 Kallar Aquifer System are

- ❖ Poor Yielding aquifers
- ❖ Drying up of shallow wells
- ❖ Decrease in yield of borewells affecting the sustainability of abstraction structures
- ❖ Insitu Salinity
- ❖ Limited scope for Artificial Recharge Schemes in the saline tracts of the basin
- ❖ Limited freshwater availability in sedimentary areas occuring as floating lenses makes the coastal tract vulnerable for water quality changes
- ❖ Pollution of groundwater due to industrial effluents

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

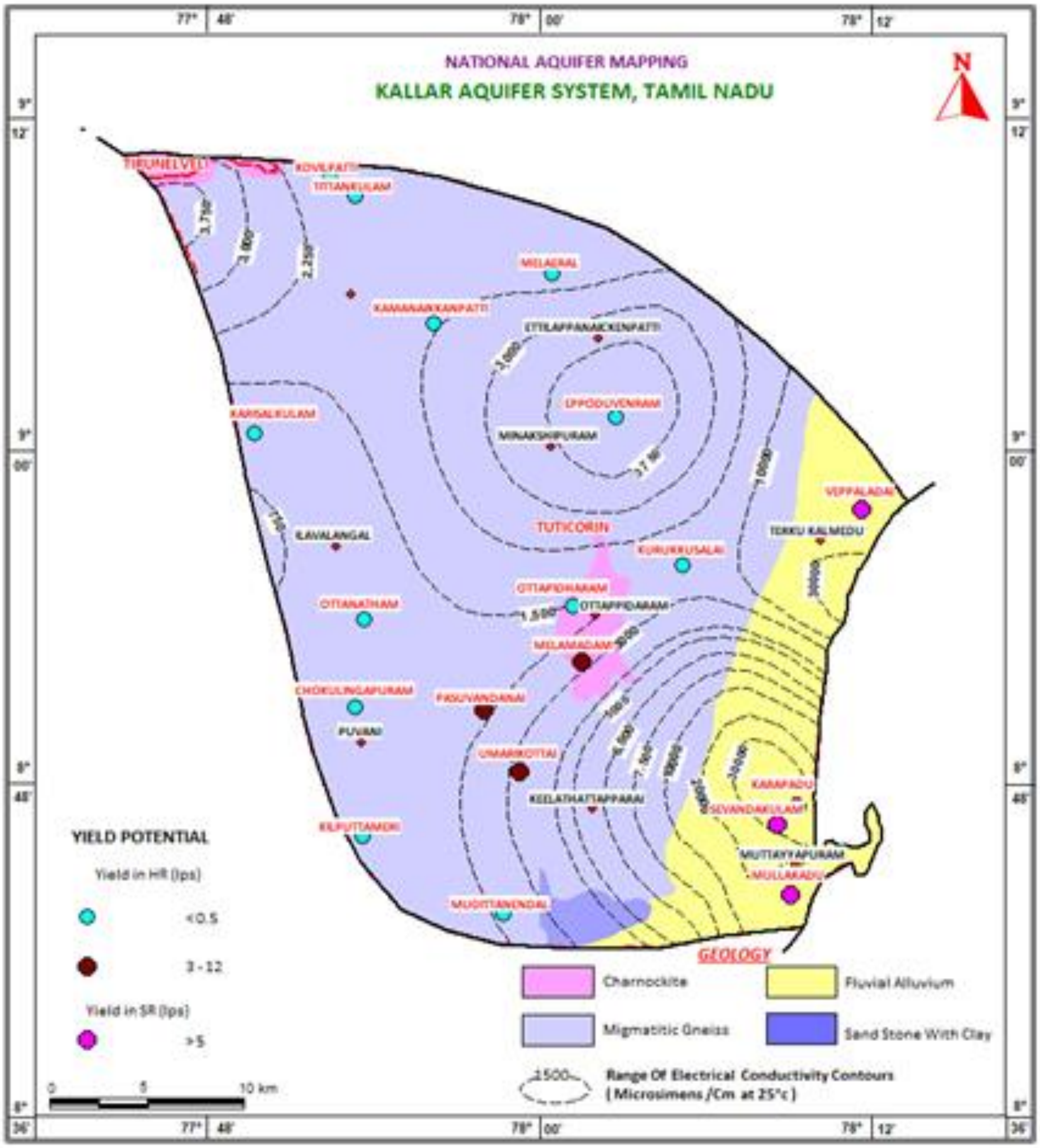


Figure1: Issues pertaining to the Kallar Aquifer system

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 Kallar aquifer system covering an area of 1691 sq. km and lies in the eastern part of Thoothukudy district. This basin is surrounded byVaippar basin on the north, Tamiraparani basin on the west and south and the Gulf of Mannar on theeast.There are two rivers in this basin, the*Kallarriver* in the northern part and *Korampallamaru* in the southern part.

Thoothukudy constitutes the municipal corporation is the largest city lying in the Kallar aquifer system and other major towns lying in the Kallar aquifer system are Theni, Andippatty, Chozhavandhan, Edaikkaattur, Mana Madurai, Paramakkudi, and Ramanathapuram.

This aquifer system covers 19firkas of which the Parivalikottaifirka falls under the stressed category, Critical .Other stressed firkasincludeNallathimputhur, Kammanaickanpatty, Kadambur, Pasuvanthanai and Ottapidaram. The hard rock formations in these areas are poor aquifers with limited groundwater prospects. The administrative map of the Kallar aquifer system is presented as **Figure 2.**

1.6. Data availability

During the aquifer mapping period, existingdataof 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, landuse&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 52 wells drilled by CGWB (19 Nos.) and State Departments (33 Nos.). Water level (32 Nos.) and water quality monitoring data (30 Nos.) data are available for a long period i.e., more than ten years. Seventyfourvertical electrical sounding (VES) data are available. 19 VES from inhouse and 55 carried out by WAPCOS. 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 35 Nos. have been established to monitor the first phreatic aquifer and 6 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 35 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 Kallar aquifer system experiences a hot semi-arid climatecharacterised by sweltering summers, hot winters and occasional heavy rain during the northeast monsoon. Summer extends from March to June when the climate is very humid. The Basin receives adequate rainfall only during the months of October and November. The area receives around 444 mm rainfall from the Northeast monsoon, 117.7 mm during summer, 74.6 mm during winter and 63.1 mm during the South-west monsoon season. The coolest month is January and the hottest months are from May to June. 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 Kallar aquifer system is 698mm which is the lowest recorded in the state when compared to the State average of 987 mm.

1.10 Physiography and Drainage

The Kallar basin lies in the eastern parts of the Thoothukudi district and covers an area of 1691sq.km. The rivers namely *Kallar* (Malattarodai), *Korampallamaru* (Upparodai) and *Chalikulamaru*form the Kallar river basin**(Figure 3).** The topography of the Kallar basin is plain with gentle slope towardssoutheast. The slope is interrupted by the presence of local outcrops or low-ridged hills, rocky knobs,bouldersandstonywaste.

There are two big tanks in the basin viz., Eppothumventran tank located in Kallar (Malattarodai)sub basin and Korampallam tank which received water from Tamiraparaniriver, from North maincanalofSrivaikundamAnicut.

Coastal plain extends from Panaiyur and Kallurani villages in the north to Kuliankarisal andPullivadi village in the south and this area is mainly covered by fairly dense scrub, open dense scruband saltpans. Two major salt factories are located in Kallar basin, one is Veppalodai in the north andthe otherisTuticorinsaltfactoryinthe south.Theotherimportantsaltfactoriesare Arasadi,AlankaratettuandPullivadi.

The maximum elevationis 253m at the southern part of Kurumalai, hillock, south of Kovilpatti and Kurumalai reserve forest at thenorth western part of basin, the entire remaining part is gradually sloping from west to east with anelevationof 100to20mMSL.

Two rivers namely *Kallar* (or Malattar) and*Korampallamaru* (Uppodai) are the main riversdraining in this basin. Besides, a small stream Chalikulamaru also drains in the middle portion ofKallarbasini.e.betweenKallarandKorampallamaru.

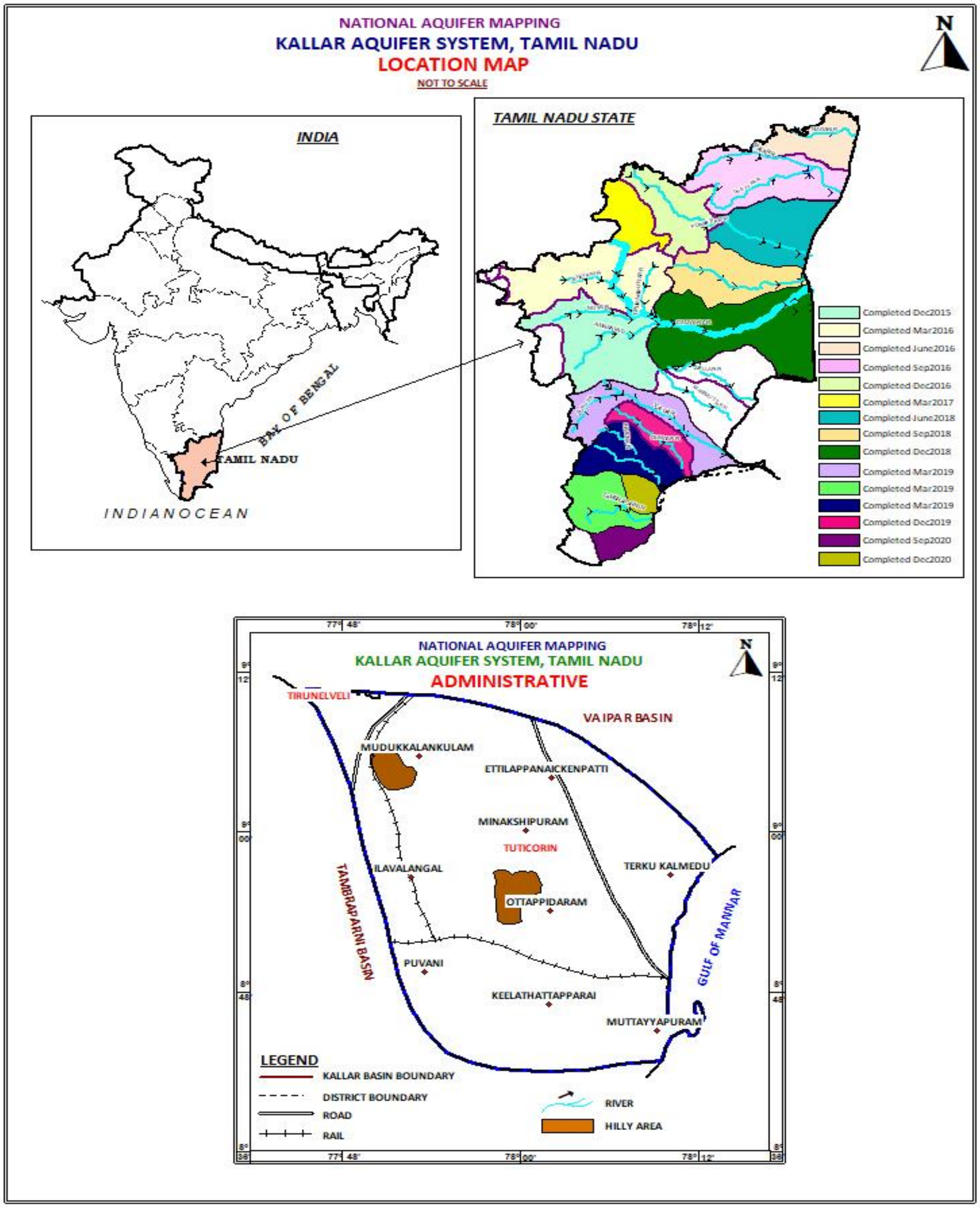


Figure 2: Administrative setup of the Kallar Aquifer system

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

Dependable Surface Water Potential for the Kallar Basin

Sl.No.	NameofSubbasin	75%DependableSurfaceWaterPotentialinMcum			
		SW	**NE**	**NM**	**Annual**
1.	Kallar	12.23	30.33	11.71	54.27
2.	ChalikulamAru	0.52	8.79	0.68	9.99
3.	KorampallamAru	3.14	39.34	16.08	58.56
	Total	**15.89**	**78.46**	**28.47**	**122.82**
South West Monsoon Potential		**15.89(or) 16Mcum**			
North East Monsoon Potential		**78.46(or)79Mcum**			
NonMonsoonPotential		**28.47(or)28Mcum**			
Annual Potential		**122.82 (or)123Mcum**			

Source : PWD report

The Existing SurfaceWaterSupply Systems

In the Kallar Basin, the surface water is drawn for usage from tanks. The tanks are classified as System tanks and Nonsystem 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 by the anicuts acrossthe river apart from the direct runoff from their own catchment.

Anicuts Details

There are eight anicuts in the Kallar subbasin, namely Ketchilapuram, Sivanthipatti,T.Duraiyoor, Athikinar, KattabommanrightandKattabomman left, Pattinamaruthur and Melaarasadi.TheKorampallam Aru subbasin has four anicuts namely Araikulam I, AraikulamII,Peruraniand Alantha.

Tanks

There are about 199 tanks in this basin including the isolated tanks by which 4146 ha are beingirrigated. Out of the above, 15 are system tanks and 184 are non-system tanks. The total storage capacityof these tanks is 43.41 Mcum. In KorampallamAru sub basin, the Korampallam tank is the last tankhaving an ayacut of 578.51 ha.

In addition to the drainage from its own catchment, it receives water from the adjacent basin from the perennial river Tamiraparani through North Main Channel of Srivaikundam anicut. The 50% of the requirement of water for this ayacut can be assumed as met through this diversion which works out to 6.59 Mcum at 44% irrigation efficiency. Details provided in the table below:

Nameofthetank	**Registered Ayacut (ha)**	**CapacityinMCM**	**Water Spreadareainha**	**No.offillings**
1)AthikinarTank	128.70	0.36	39.22	1.90
2)AthilodaiTank	56.82	1.00	43.65	0.29
3)Avarankulam (Keelamodiman)	52.01	0.62	46.71	0.54
4)Bommiyarpuram	64.45	0.57	54.09	-
5)EpppodumvendranTank	164.05	3.53	259.60	2.00
6)KandasamiyapuramTank	43.76	0.66	41.03	2.76
7)KannakottaiTank	85.44	0.55	68.24	0.28
8)Karisalkulam(Duraiyur)	66.03	0.44	65.69	2.00
9)Karisalkulam(Vellaram)	59.09	0.92	66.50	0.43
10)KilaripattiTank	45.34	0.53	56.83	1.00
11)KilmodimanTank	87.11	1.04	69.96	0.23
12)Kolathur(South)	63.26	-	7.40	1.06
13)Kollamparambukulam	160.08	0.72	103.07	2.00
14)OttanathamTank	43.72	0.33	27.17	2.00
15)OttapidaramBigTank	40.64	1.04	70.55	2.50
16)PanchathangiTank	80.34	0.51	70.33	1.39
17)PattanamarudurTank	84.58	1.73	150.03	0.61

18) PeethapuramTank	73.39	0.84	55.30	1.12
19)PeriyanathamTank	41.71	0.80	65.62	0.93
20)SevalkulamKarisalkulam	62.43	0.88	65.69	0.61

Interbasin transfer of water

Water is diverted from Tamiraparani Basin through North Main Channel taking off fromSrivaikundam Anicut, the last anicut across Tamiraparani river for thermal power generation etc. and thequantityof waterdivertedis10.78MCM. The water also finds use in irrigating the lower riparian stretches of the basin.

1.11Geomorphology

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

The prominent geomorphic units identified in the Basin are 1) Fluvial, 2) Marine, 3) Fluvio-marine, 4) Aeolian and 5) Erosional landforms depending on the environment of formation. Taruvaikulam- Tuticorin surface, Kulattur surface, Vaippar surface, Nagalapuram-Vedanattham surface and Volinokkam-Vembar surface are some of the erosional geomorphic units in the northern part of the Basin. Karamaniyar surface, Tambraparni surface, Tiruchendur-Kayapattinam surface and Vallanadu surface are the geomorphic units in the southern part of the Basin. The number of red sandy tracts formed of the sand dunes locally known as Teri sand complex are the important feature in the coast. These Teri sands extend in width from 6 to 8 km from the coast. Adaippanvilai Teri, Kudiraimozhiteri and Vaippar-Vembar Teri are some of the important Teri areas, which are having elevation in the range of 15 to 62m above MSL. The sand flat is another feature of the coast comprising of clays and silts, often inundated by seawater and encrusted with salt.

About 75% 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 Kallarriver in the South eastern part. **Figure 4** and **Figure 5** illustrates the level I classification of geomorphological features of the Kallar 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.

Agricultural land occupies nearly, 66 % of the Kallar aquifer system area and spread throughout the study area. Built up/urban area, Barren and water bodies, occupy 18 %, 14 %and 2 % of the area respectively. Landuse and land cover is represented in **Figure 6 & 6a.**

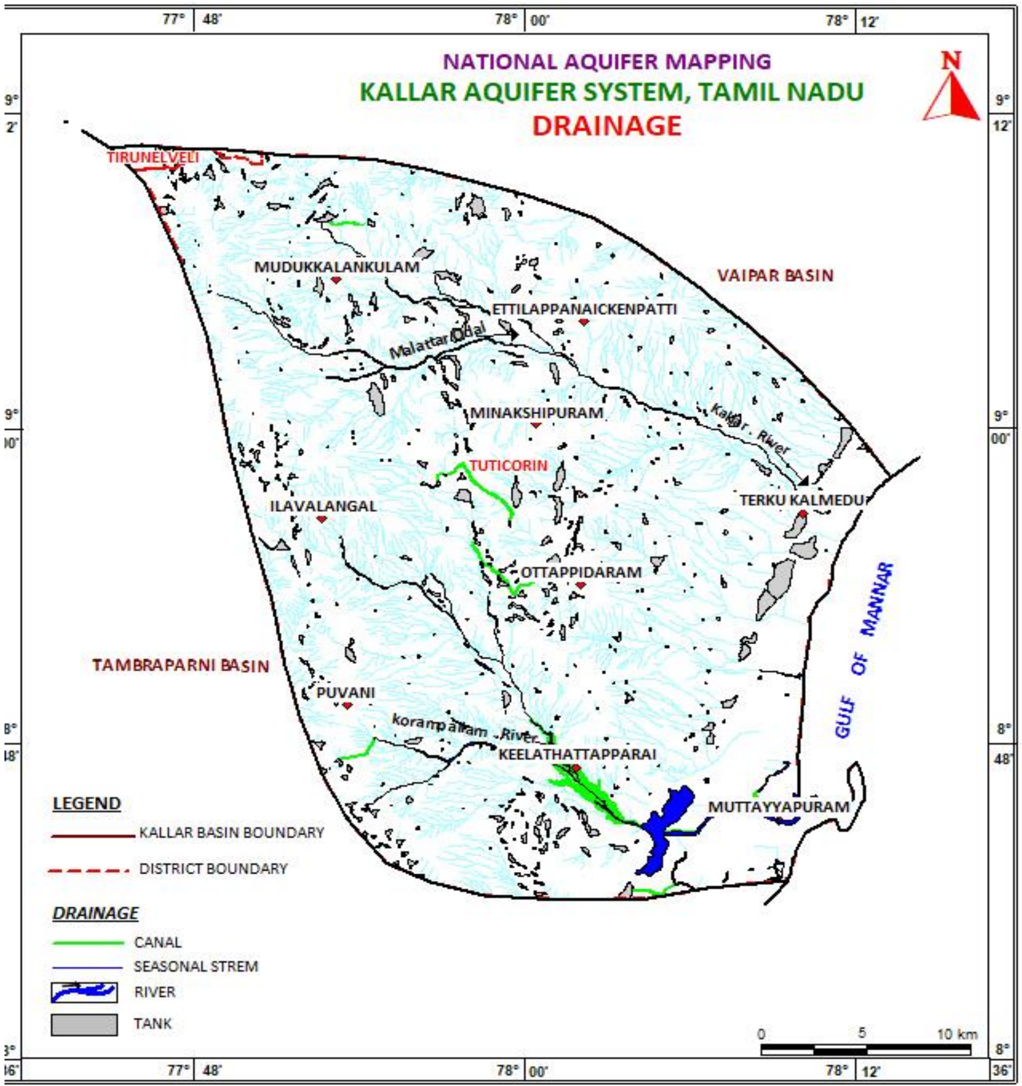


Figure 3: Drainage map of the Kallar aquifer system

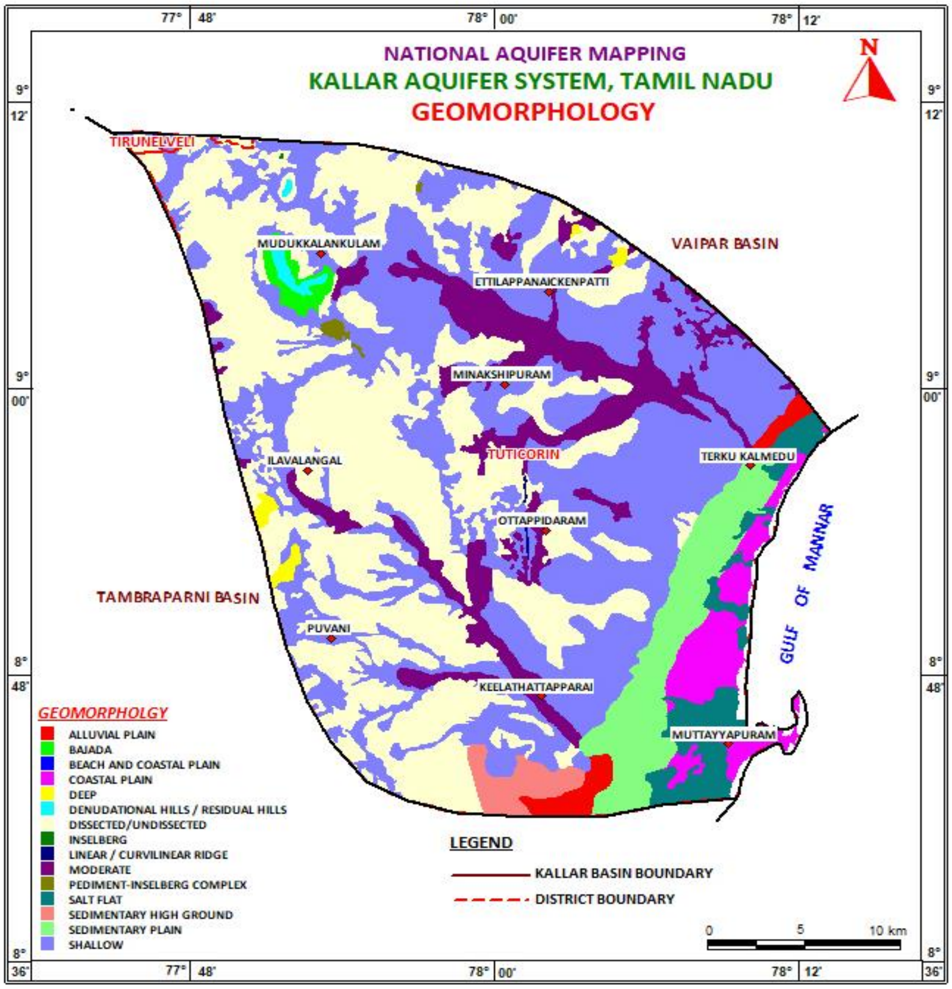


Figure 4: Geomorphology map of the Kallar aquifer system

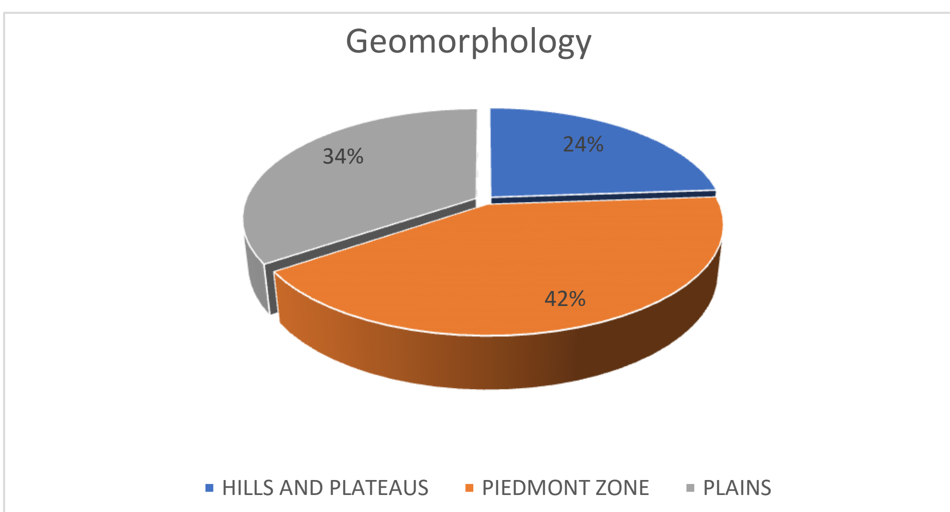


Figure 5: Level I classification of geomorphology of the Kallar aquifer system

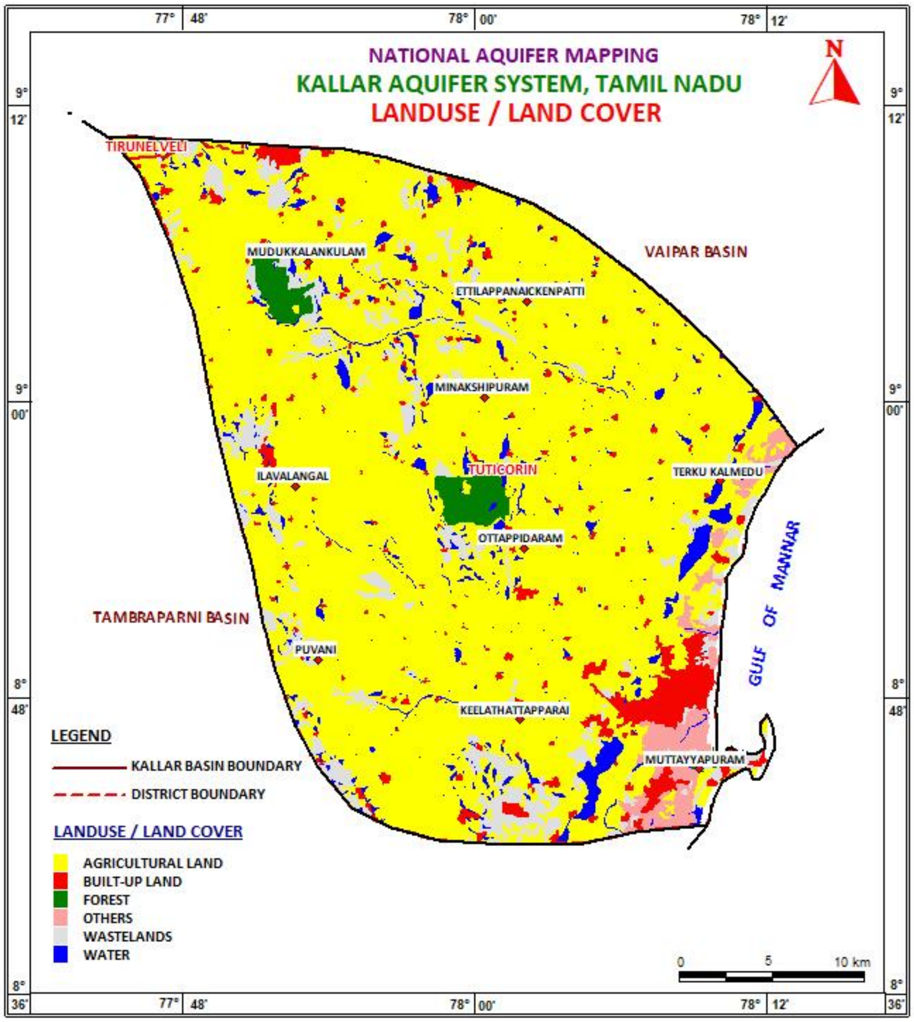


Figure 6: Level 3 Landuse /Land cover map of the Kallar aquifer system

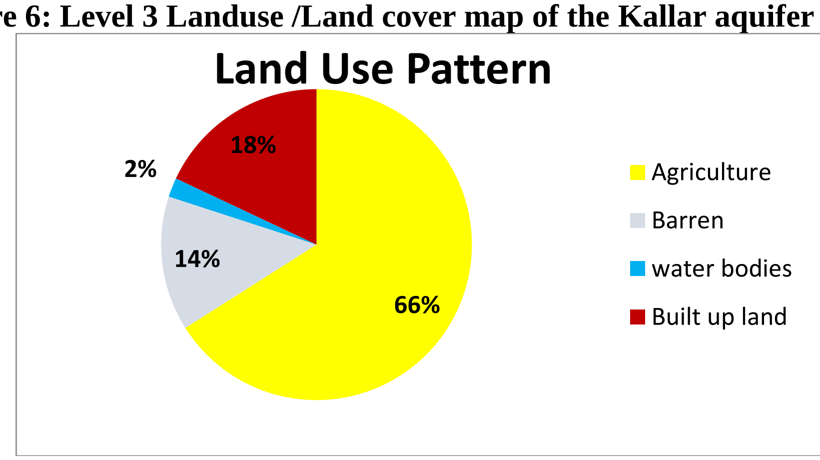


Figure 6a: Level 1 Landuse/Land analysis diagram of the Kallar aquifer system

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**)

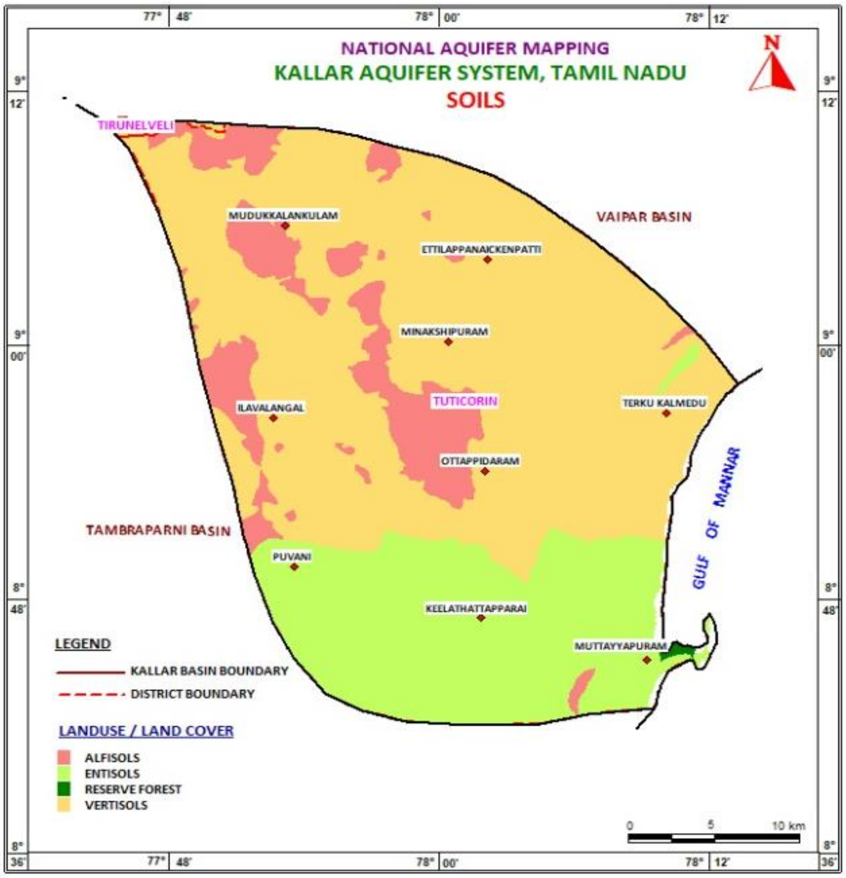


Figure 7: Soil map of Kallar aquifer system

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 1**

Table 1: Details of area irrigated and cultivated under wet and dry crops (Kallar Basin)

District	**Firka**			**Area irrigated as % of**	
		Area irrigated	Area cultivated	Area irrigated	Area cultivated
Thoothukudi	Kalugumalai	85.885	10050	0.847336	0.854577
Thoothukudi	Nallathinputhur	248.3	5247	4.518407	4.732228
Thoothukudi	Ettayapuram	99	6493	1.50182	1.524719
Thoothukudi	Kammanaickanpatti	203.5	6631	2.97754	3.068919
Thoothukudi	Kadambur	570.025	7922	6.712474	7.195468
Thoothukudi	Parivalikotatti	354	8096	4.189349	4.37253
Thoothukudi	Cholapuram	180.64	3734	4.614473	4.837708
Thoothukudi	Sivagnanapuram	2	10136	0.019728	0.019732
Thoothukudi	Pasuvanthanai	235	6878	3.30381	3.416691
Thoothukudi	Eppodumvendram	15	7038	0.212675	0.213129
Thoothukudi	Maniyachi	52.23	5682	0.910846	0.919219
Thoothukudi	Ottapidaram	367	48.7	88.28482	753.5934
Thoothukudi	Vedanatham	51	3100	1.618534	1.645161
Thoothukudi	Vallanad	696	4084	14.56067	17.04212
Thoothukudi	Keelathataparai	56.73	1472	3.710923	3.85394
Thoothukudi	Deivasayalpuram	131.94	3249	3.902465	4.060942
Thoothukudi	Mudivaithanandal	299	1178	20.24374	25.382
Thoothukudi	Pudukottai	128.4	978	11.60521	13.12883
Basin Total		3775.65	92016.7		

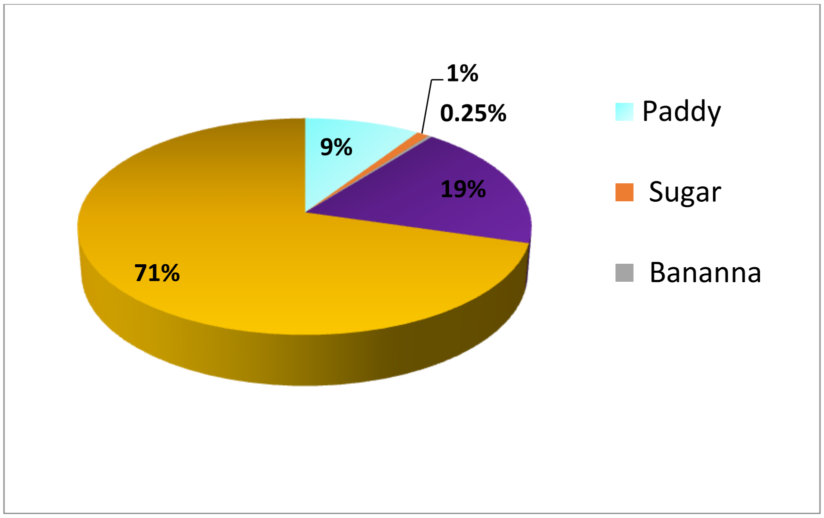


Figure 8: Crop wise distribution in the Kallar aquifer system

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 5006 ha of the basin is under irrigated agriculture. The details of area under various sources are furnished in the **Table2** below

Table2: Net area irrigated by different sources in Kallar basin

Sl No.	Source of Irrigation	Area irrigated (ha)	Area irrigated as % of total area irrigated	Area irrigated as % of total cropped area	Irrigation intensity
1	Canals	405	8.07	0.40	1.03
2	Tanks	1064	21.26	1.06	1.54
3	Tube wells	150	3.00	0.15	1.02
4	Dug wells	3387	67.67	3.36	1.15
		5006	**100.00**	**4.97**	

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 1.54 for tanks to 2.17 percent for wells. Tha average intensity of irrigation for the basin for the year 2016-17 works out at 1.03 %.

1.16 Geology

Major parts of Kallar basin area is traversed by Garnetiferous biotite gneiss. Besides, charnockite occupies a small pocket in and around Ottapidaram. Narrow linear bands of quartzite and pink granitetrending N-S direction find a place amidst the country rock.Lime stones of calc granulite as linear patchesalso found on the eastand northern partsof Ottapidaram. This rock occurs as xenoliths within the country rock.**(Figure 9)**

In the coastal tracts, dunes of white sand and red 'teri' sands of recent origin parallel to the coast are found. The red coloured 'teri' sands form small dunes rising to an average height of 15m from the adjoining plains. The sand also occurs as a thin capping over the Sub-Recent (Quaternary) sandstone and limestone at places.The alluvium is confined to a very narrow belt on the bank of the rivers of Kallar river &Korampallamaru. This consists of brownish black to reddish brown sandy clay with a small proportion of silt.The geology with lineament map is shown below. The frequency of lineaments is more in the area covering in between Ettaiyapuram, Veppaolodai, Mel Arasadi and Ottapidaram. The NW-SE and NNW-SSE trending lineaments are predominantly traversing in these areas.East-West trending lineaments are cutting across the above two sets of lineaments and developed more number of lineament intersection points. The geology and lineament map generated in the GIS environ show positive ways todevelopgroundwaterinthissemi-ariddrybeltofKallar.**(Figure 9a)**

More number of lineaments is noticed in pink granite patches; swarms of calcgranite and quartzite are concentrated in this highly disturbed zone. The depth of the fractured zone extendupto 50m but in four isolated portion the fractured zone is touched at a depth of 50m. In Maniyachi, Ottainattam, Tottanpattai, Pungavarnattam, Arnikkulam, Tattaparai and further down uptoMelvagaikulam, the fractured zones may be encountered upto a depth of 50m.

Western part of Ottapidaram and Ettaiyapuram is showing N-S, EW and ENE-WSW trending lineaments. These lineaments are less in numbers and displaced. North –South trending lineaments areshowing parallelism to the linear pink granite occurring in the middle part of basin area. The intersections of lineaments with pink granites and quartzites, geological contact with lineament intersection points are very good ground water potential zones. But in such zones the quality varying good to saline in the easternpart and coastal areas. The garnetiferous biotite gneiss is covering 83% of the total area of the basin and 97% total area of the hard rock. 15% of the total area of the basin is underlain by the sedimentaries bordering the South eastern portion of the basin adjoining the Bay of Bengal. Wherever the calc granite /crystalline limestone and quartzite formations are contacting the garnetiferous gneiss, such contacts zone can be taken for groundwater exploration in the first order of priority.

Lineament –drainage course: major river courses are controlled by the NW-SE, E-W and WNW-ESElineaments. These streams are filling the secondary aquifers and recharge groundwater.

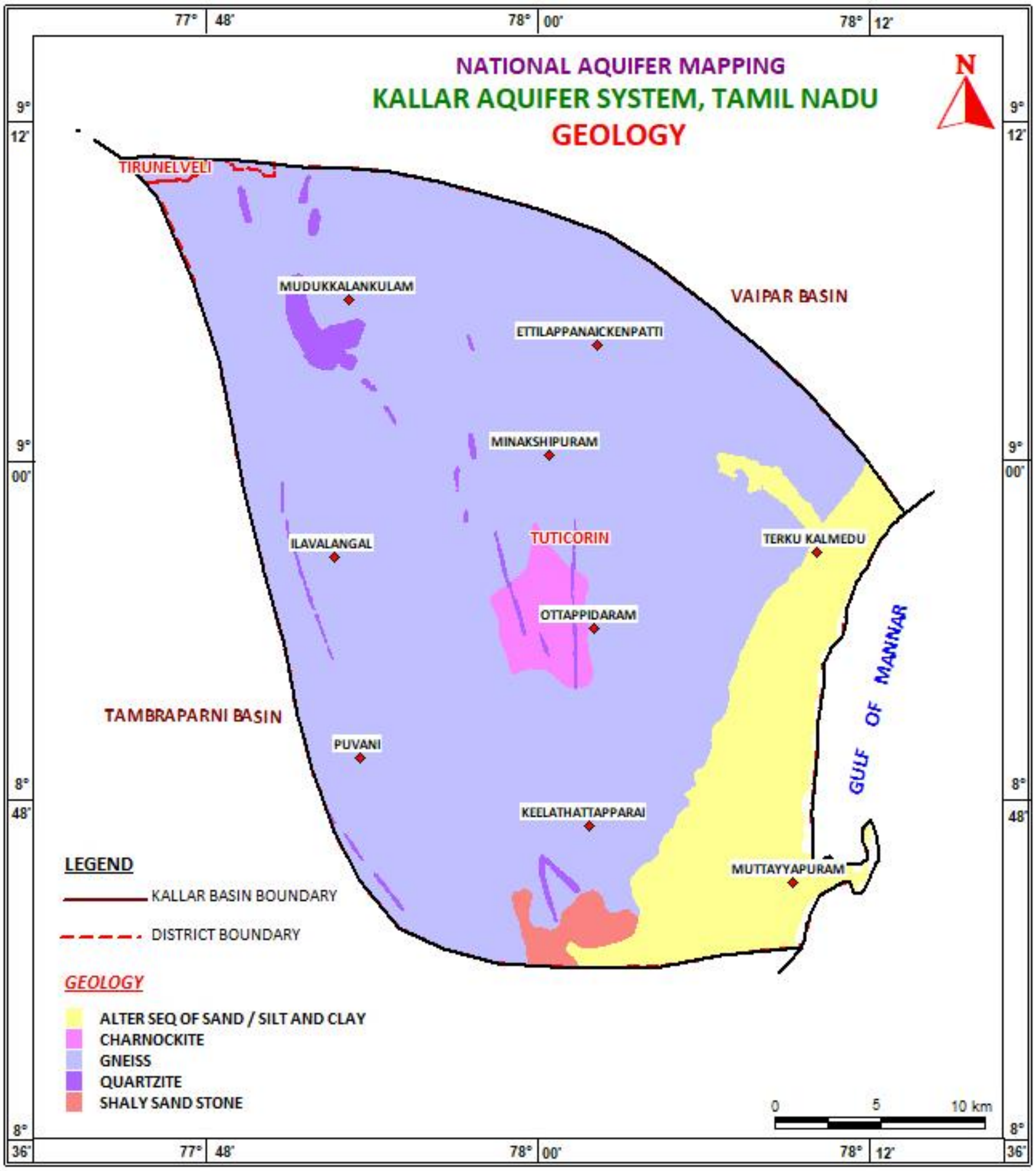


Figure9: Geological map of the KallarAquifer system

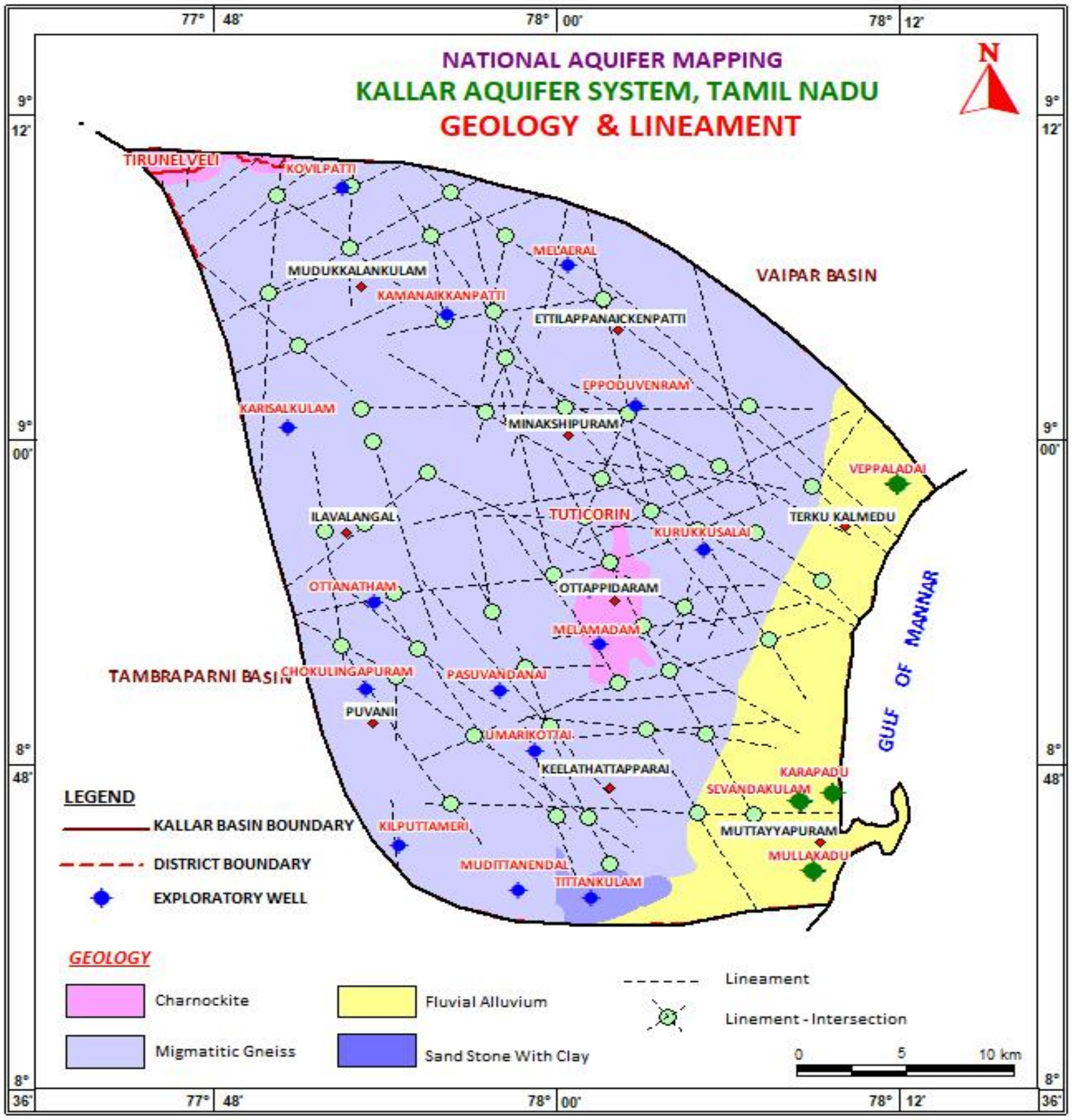


Figure9a: Geological map of the KallarAquifer system

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 Kallar 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 Kallar 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 Kallar 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 19 VES were carried out and geo electric layers inferred through interpretation of the results obtained. 55 VES were conducted through outsourcing during the NAQUIM studies to have an even understanding of the subsurface disposition of the aquifer systems. The adoption of this non invasive technology has been useful for successful interpretation of the aquifer disposition with an added advantage of economical benefit over the exploratory wells. The locations of the VES are presented in **Figure 12.**

2.4 Groundwater Exploration data:

Data of 52 Nos. of exploratory wells were drilled in the Kallar aquifer system (19 Nos. CGWB and 33 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, 8 Nos. of exploratory wells have been recommended for drilling through outsourcing activity as part of the data generation.The wells have been drilled at the proposed sites. 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, 33Nos. wells drilled upto to the depth of 60 m bgl was used for deciphering the first aquifer.

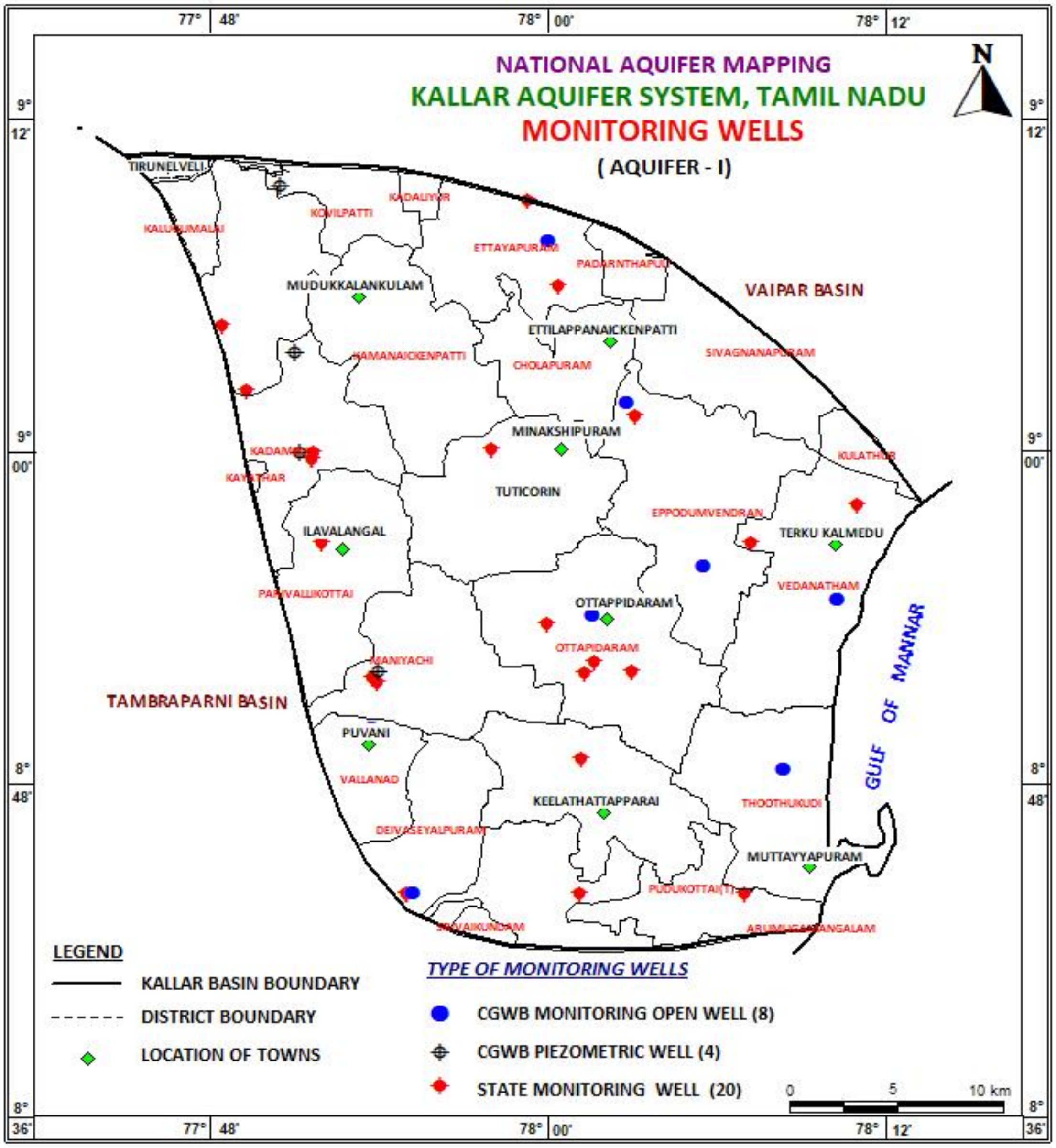


Figure 10. The locations of monitoring wells of the Kallar aquifer system.

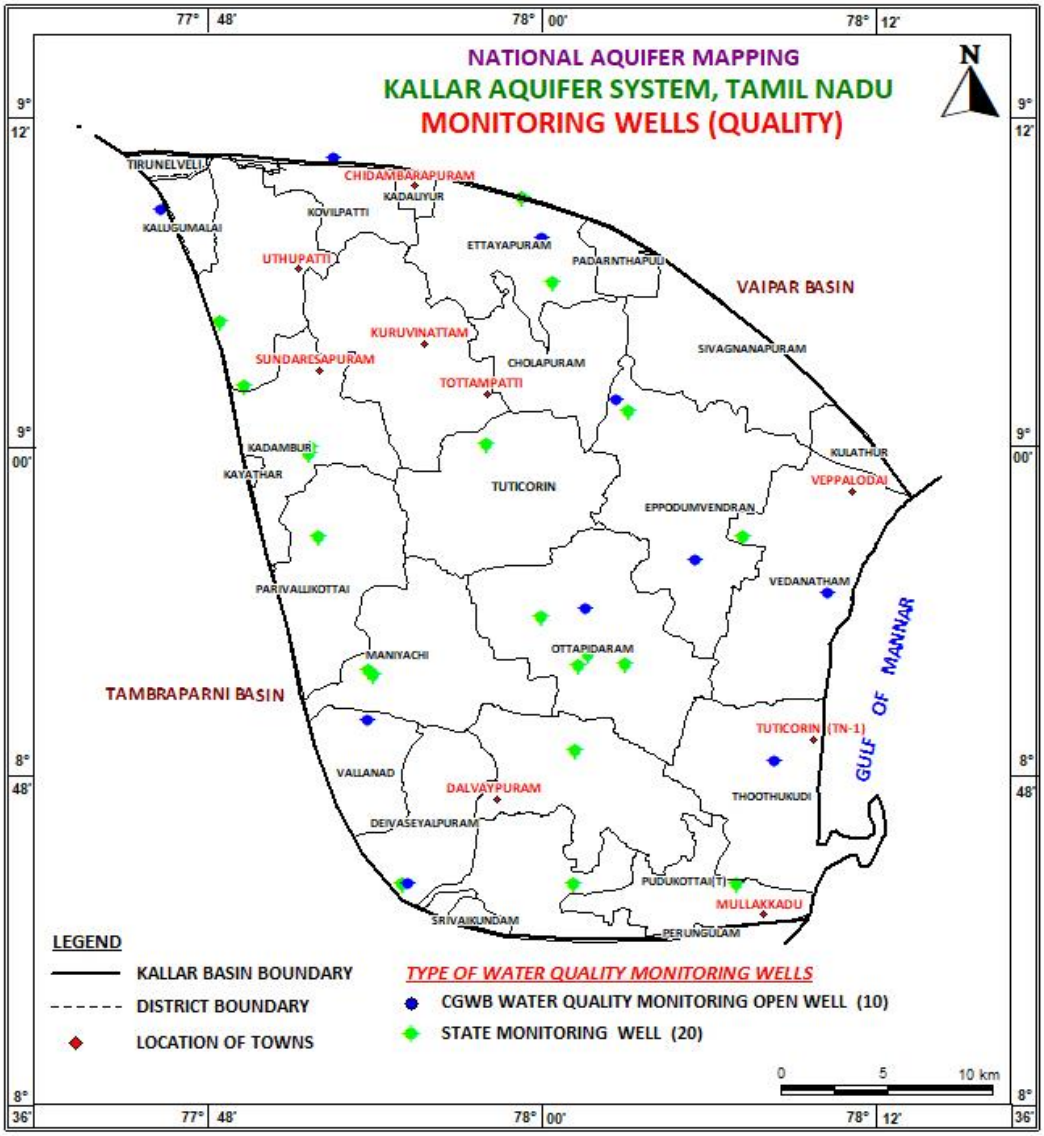


Figure 11. Locations of Groundwater quality Monitoring Wells ofKallar Aquifer System

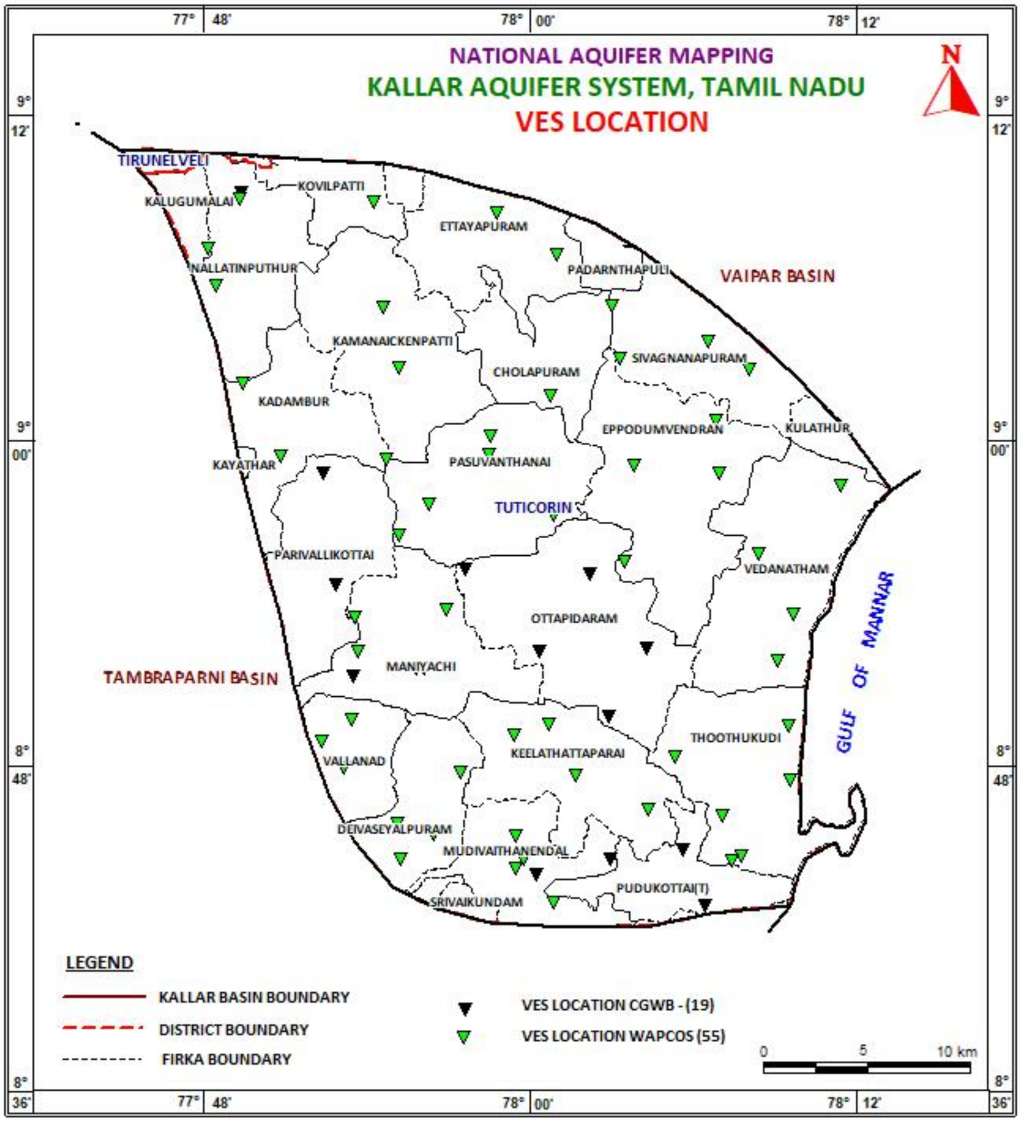


Figure 12. Locations of Vertical Electrical Soundings (VES) of Kallar Aquifer System

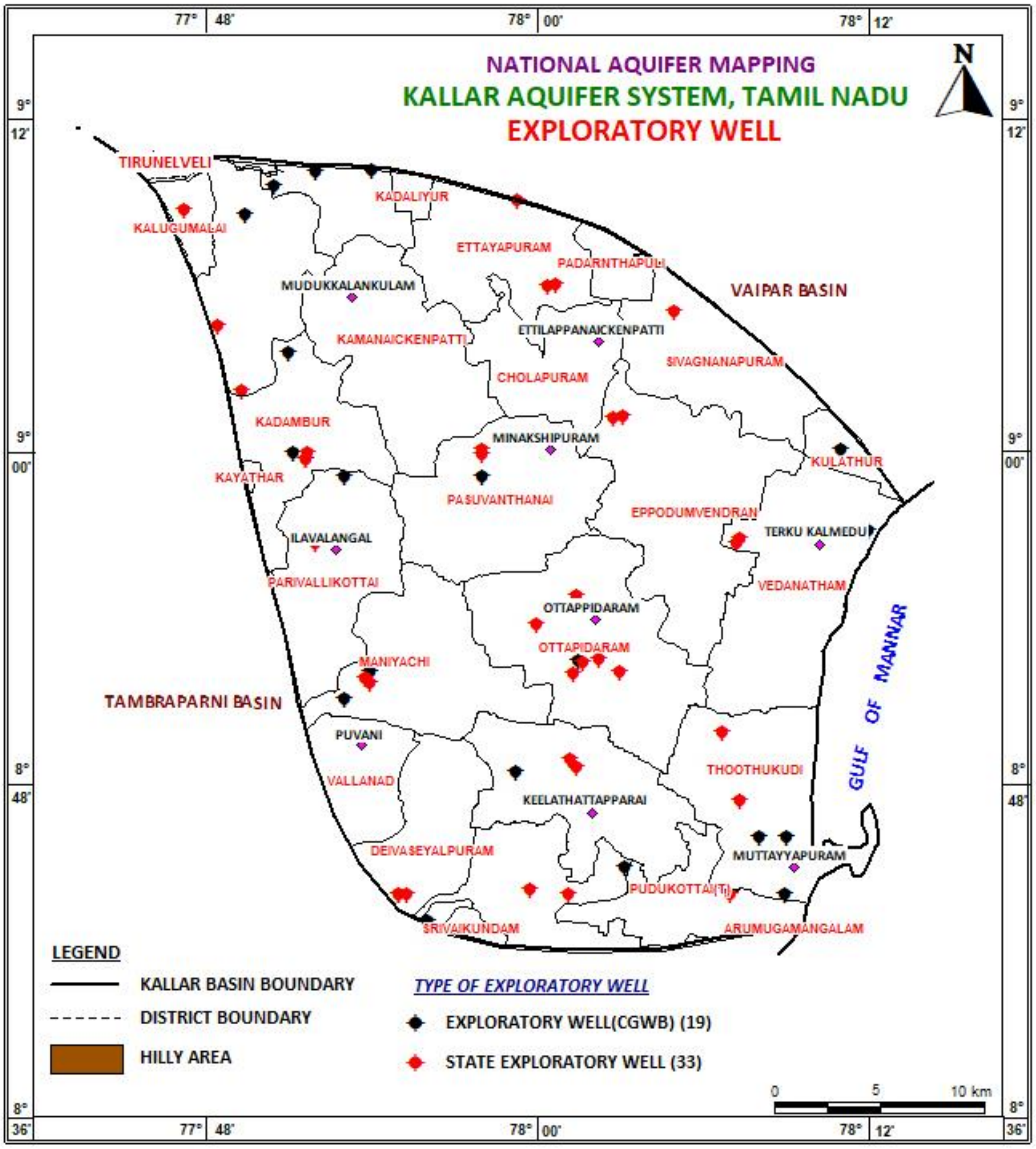


Figure 13. Locations of all Exploratory WellsofKallar Aquifer System

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeological Data Interpretation and aquifer disposition

Kallar Aquifer system area predominantly comprises of the Precambrian crystallines, granite gneisses being the major rock type. Also minor occurrences of sedimentaries flank the south eastern part of the basin. The hard rock aquifer system is futher subdivided into two units the weathered and the fissured/ fractured units. The sedimentaries are the multi layered aquifer system with formations ranging from Recent to Cretaceous formations (Alluvium, Tertiary and cretaceous sandstone)

3.1.1. Hydrogeology of hard rock region

Hard rock region comprising of Gneissic rocks is spread in almost the entire basin except along the soutnern flanks which is occupied by the sedimetaries (15% area of the basin) andpatchy occurrence of Charnockite rocks(B)(3% of the hard rock area) found in the central portion of the Kallar aquifer system. Hard rock regions cover an area of 1490sq,km. The gneissic formation covering an area of 1452 sq.km encompasses 15firkas**(Table 3).**The Charnockite formation covers an area of39sq.km and is found in 1firka. 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

Gneiss 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 Gneiss formation. Yield of this weathered aquifer unit ranges from 0.72 to9m^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, Kallar Aquifer System is shown in **Figure 14.**

Table3: Firkasalong the various geological formations across Kallar aquifer system.

Gneiss &Charnockites (Firkas - 16 Nos)	Sedimentary (Firkas – 3 Nos)
Kalugumalai	Pudukottai
Nallathinputhur	Thoothukudi
Ettayapuram	Vedanatham
Kammanaickanpatti	
Kadambur	
Parivalikotatti	
Cholapuram	
Sivagnanapuram	
Pasuvanthanai	
Eppodumvendram	
Maniyachi	
Vallanad	
Keelathatparai	
Deivasayalpuram	
Mudivaithanandal Ottapidaram (Charnockite)	

Aquifer parameters in Hard rock area

S.No.	Parameter	Minimumvalue	Maximumvalue
1.	SpecificCapacity	1.20lpm/mdrawdown	118lpm/mdrawdown
2.	Transmissivity(T)value	0.45 m^2/day	338m^2/day
3.	Storativity(S)value	2.60x10^{-5}	3.60 x10^{-5}
4.	Yield	60.00 lpm	180lpm

Charnockite rock area

In the area covered by charnockites 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)

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 general3 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 4.** 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 **.** The general EC of this aquifer unit ranges from 370 to 2010 µS/cm.

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 5.**The yield of this aquifer unit II ranges from 5 to 43 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 010 to 442 m^2/day **(Table 5).** The general EC of this aquifer unit ranges from 440 to 3800µS/cm.

Table 4: 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	45	Upto 50	12.5
50 to 100	15	50 to 100	12.5
100 to 200	35	100 to 150	37.5

Table 5: Salient features of the aquifer units in hardrock ofKallar aquifer system

Type of Aquifer	Formation	Top & Bottom of	Thickness/ occurrence of	Range of Yield (m3/h)	Sustainability (hrs)	Aquifer parameter (Transmissivity –	EC values (µs/c	Suitable for Drinking
Aquifer unit - I	Weathered gneiss	Top: GL Bottom: 5 -	5 – 40 (Avg. - 20m)	1.5-25 (generally- 20 m3/hr)	Monsoon : 2-4 hrs& non monsoon	10-25	750 >2500	Yes – except pockets of
Aquifer Unit - II	Jointed & Fractured Gneiss/Charnockite	Top: 5 – 40 Bottom:	18-193 (3 to 4 fractures exist)	<5 to 43 (Avg- 5 m3/hr)	for 4-6 hours in monsoon and < 1 to	General range 10-42 578 (Melamado	400-2500	Yes – except SE parts

3.1.2. Hydrogeology of Sedimentary area of the aquifer system

Sedimentary rock region comprising of alluvium and Tertiary formations occupy the South eastern part of the aquifer system.It covers an area of 268 sq.km. sedimentary area (Alluvium, Tertiary formation& Cretaceous formation) encompasses 3firkas**(Table 6)**Alluvium and the unconfined layers of Cuddalore formations form phreatic aquifer- Aquifer unit-I, Tertiary formation is the confined aquifer unit (Cuddalore sandstone and the createaceoussandstones)defining aquifer unit II **(Table 8)**

3.1.2.1 Aquifer Unit – I (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 10 m in the area covered by river alluvium, about 15 to 20 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 alluvium varies from 15 to 25 m^3/hr. and the yield varies from 10 to15 m^3/hr in the phreatic unit of Cuddalore sandstone formation**.**

The transmissivity of alluvial formation ranges between25 and 150 m^2/day and the specific yield ranges between 12 and 18 %. Where as the transmissivity of Cuddalore sandstone formation ranges between 100 - 250 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 Kallar aquifer system.i.e. in coastal part of Thoothukudy district (Thoothukudy and Vedanathamfirka) 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 phreatic Aquifers have EC concentrations within the permissible limit generally ranging rangingbetween 250-1000 µsiemens/cm except pockets in SE and NE swaths of the basin. For Deeper Aquifer groundwater is not potable at locations Ottapidaram, Pasuvadanai, Vedanatham, Pudukottai, Kilathattaparai and Kovilpatti.

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 Ottapidaram, Pasuvadanai, Vedanatham, Pudukottai, Kilathattaparai and Kovilpatti.

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 : Tertiary sandstone

Tertiary sandstone of the Kallar 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 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 transmissivity ranges between 100 and 750 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 very high in this aquifer unit. Quality data of groundwater exploration of Cuddalore sandstone aquifers reveals that the EC. values range from 5000 to as high as 103670 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 basin is of Na-Cl-HCO_3 type.

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

Table 6: Salient features of the aquifer units in Sedimentary rock region of Kallar Aquifer System

Type of Aquifer	Formation	Top of the aquifers (mbgl)	Thickness/ occurrence up to (m)	Range of Yield (m^3/h)	Sustainability (hrs)	Aquifer parameter (Transmissivity – m2/day)	Groundwater quality EC values (µs/cm)	Suitable for Drinking
Phreatic	Alluvium/ Teri Sand	Top: GL Bottom: 5 - 20	5 – 20 (Avg. -10m)	15-25 (Average 18 m3/hr)	Monsoon : 3-4 hrs& Non monsoon: (May ,Jun&July) 2.3 hrs	25-250	646 – 2250/ >5000-	Poor quality. Fresh water lens available Presence of salinepockets.
Aquifer II	Tertiary SST	Top: 5 – 20 Bottom: 20-60	18-50	24-36	Monsoon : 8-10 hrs& Non monsoon: (May ,Jun&July) 5-6 hrs	10-70 402 (Mulakadu)	>5000- (103670 max pt value	Poor quality.

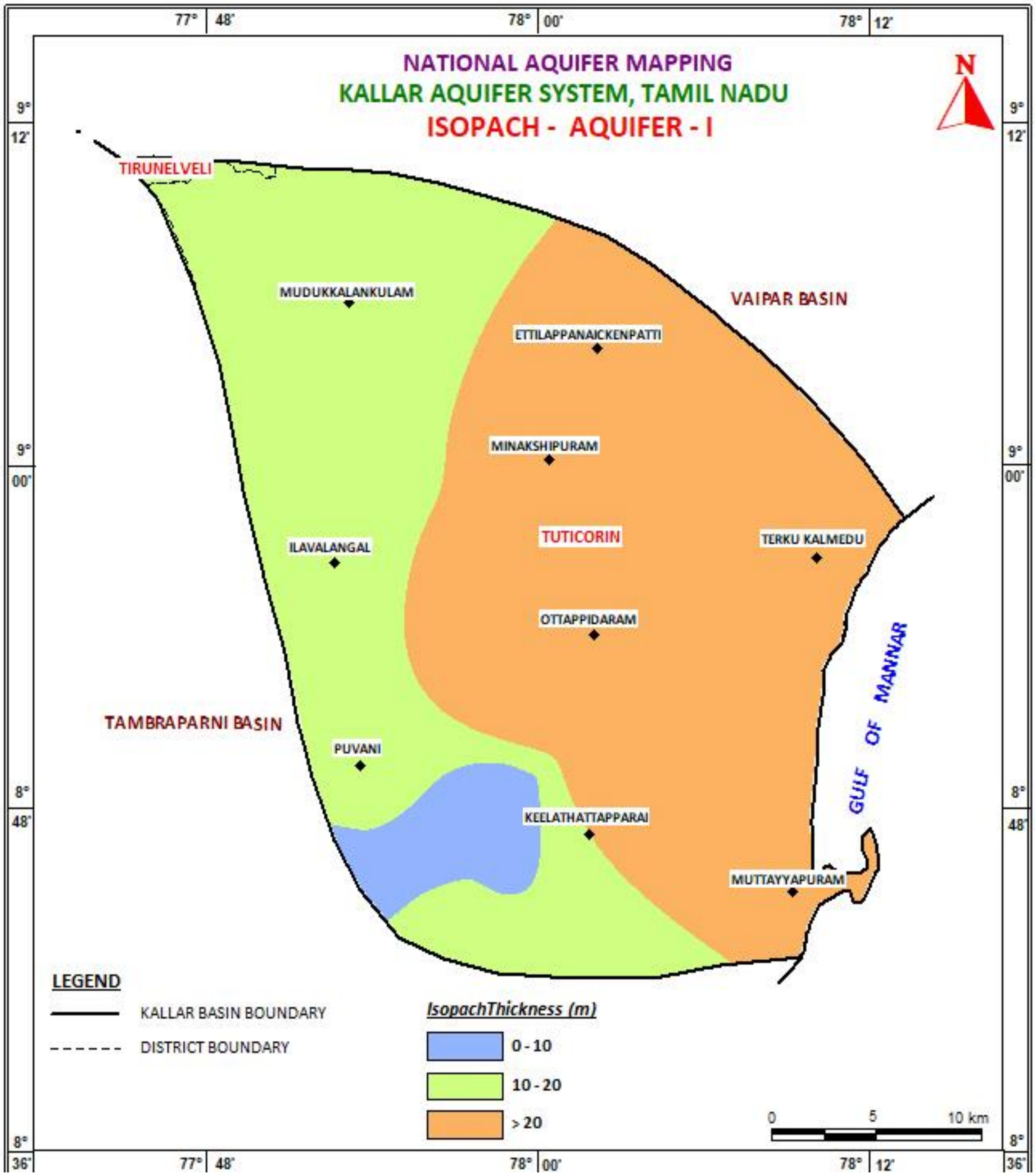


Figure 14: Weathered thickness of Aquifer-I, Kallar Aquifer System

ISOPACH

HARD ROCK

Thickness of Aquifer – I

Weathered crystalline and Alluvium forms Aquifer – I (Phreatic aquifer). In hardrock areas the thickness ranges from 5- 40mbgl. Depth of weathering increases towards East;

SEDIMENTARY

Aquifer I in the sedimentary area : 0- 22 mbgl

Max thickness observed along the southern portion

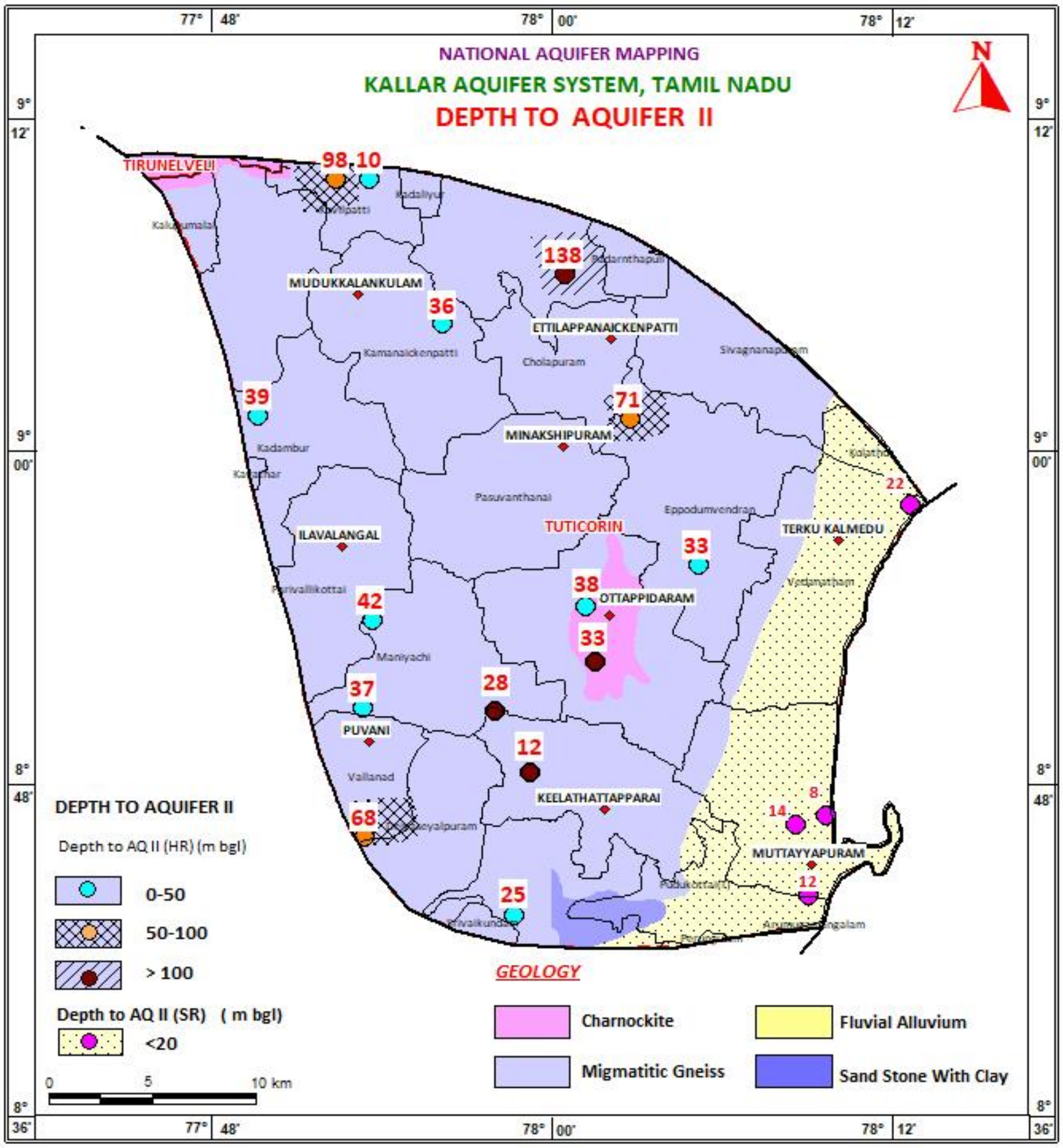


Figure 15: Depth of occurrence of Aquifer-II of Kallar Aquifer System

Hard rocks

•Number of wells drilled in HR	: 15
•Depth drilled	: 200
•Depth to occurence of first Fracture	: 10-138 m bgl
•Potential fractures encountered	: 24-193, 40% potential fractures in the range 24-38 mbgl

Sedimantaries

•Number of wells drilled in SR	: 4
•Depth drilled	: 46-70 m bgl
•Depth to AQ I	: 7-20 m bgl

3.2.Groundwater Level

During Aquifer Mapping studies in Kallar aquifer system 37groundwater monitoring wells have been established and monitored in different formations in order to know the behavior of the groundwater regime**.**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.

Depth to water level (Aquifer-I) - Premonsoon of the Kallar Aquifer System presented as **Figure 17**. Depth to water level (Aquifer-I) - Postmonsoonpresented as **Figure 18**.

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

- % of wells yield > 3lps : 20%
- High discharge wells located along NW-SE trendinglineament
- Yield of bore wells : Highest discharge of 12 lps at Melamadom , 4 lps at Umarikottai,
- Major part having yield <0.5 lps (75 % of wells)

In sedimentary areas

- Discharge ranging between 6 to 22 lps. High TDS of >10000 mg/l making the formation water brine

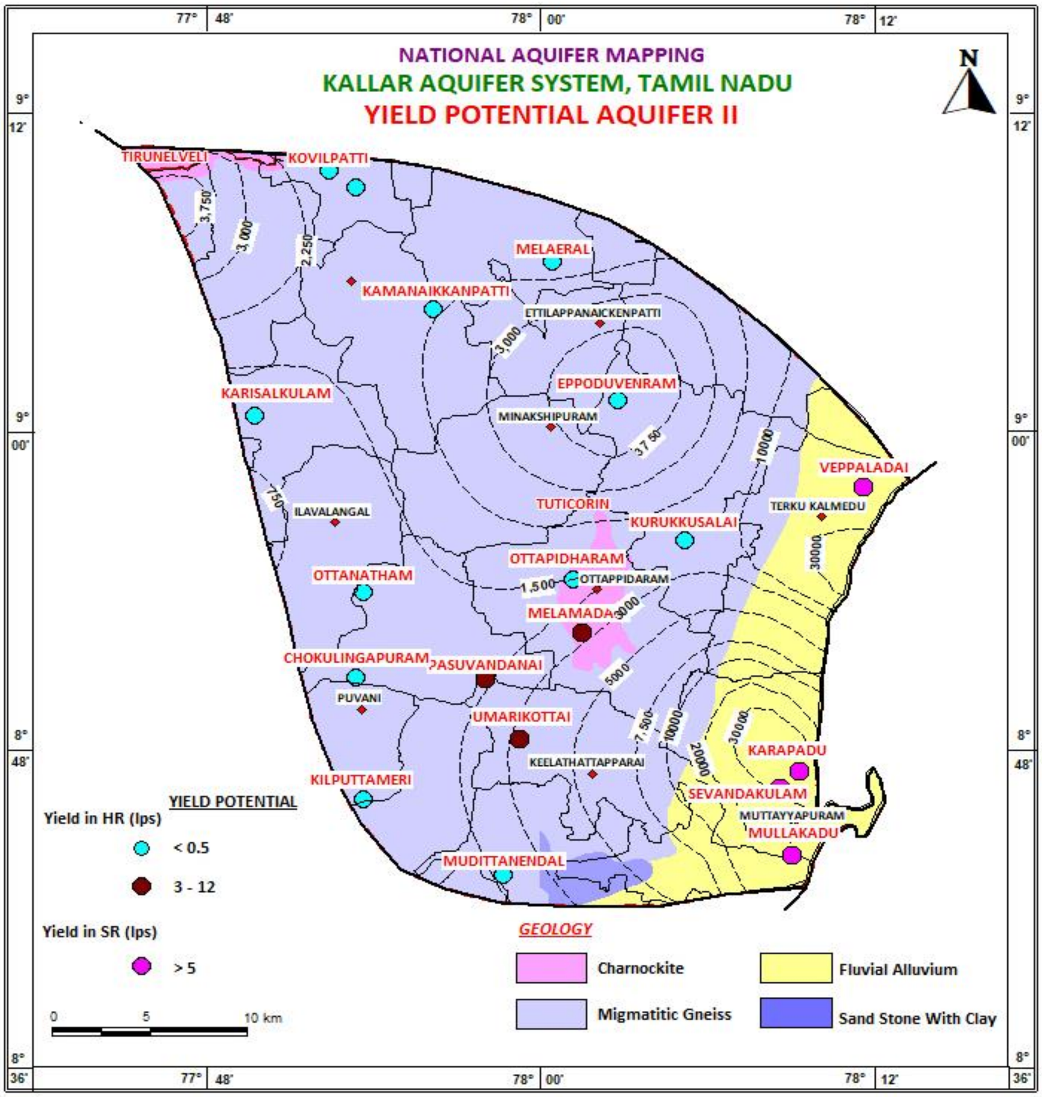


Figure 16. Hydrogeology map of the Kallar aquifer system

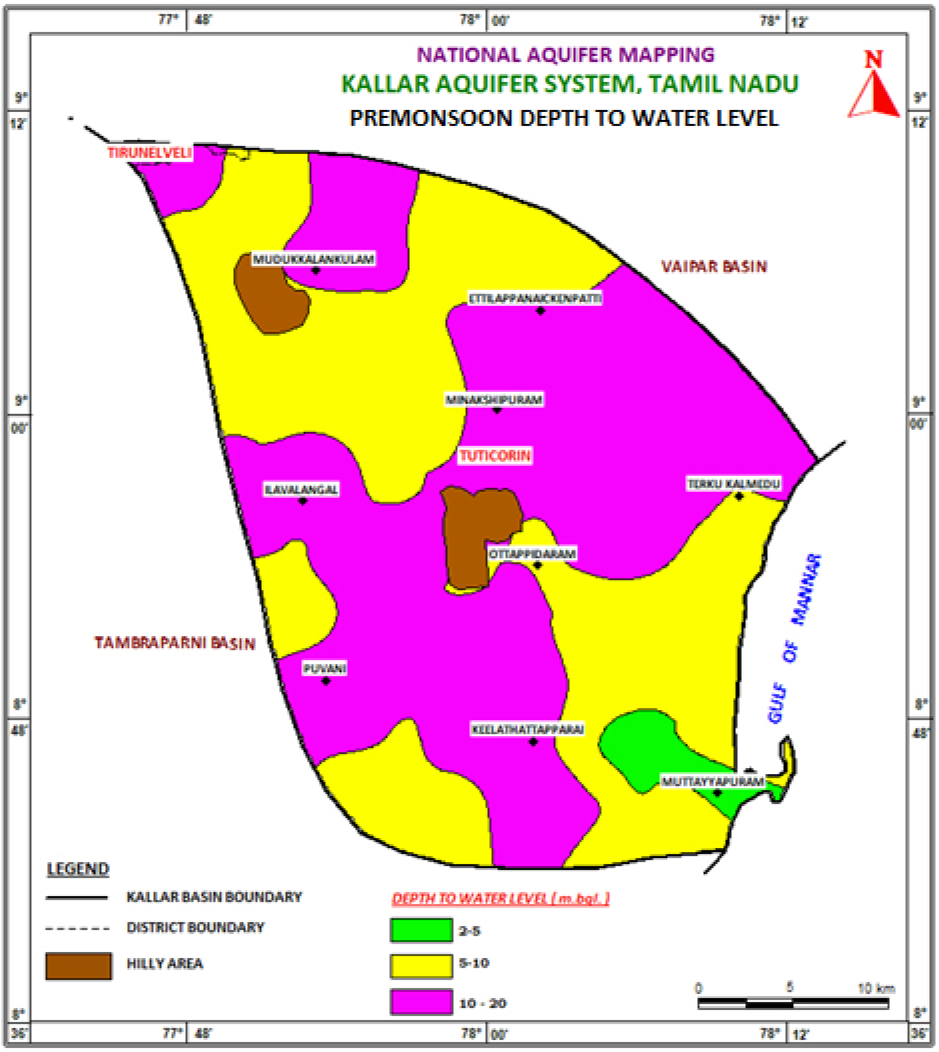


Figure 17: Depth to water level (Aquifer-I) Pre-monsoon of the Kallar aquifer system

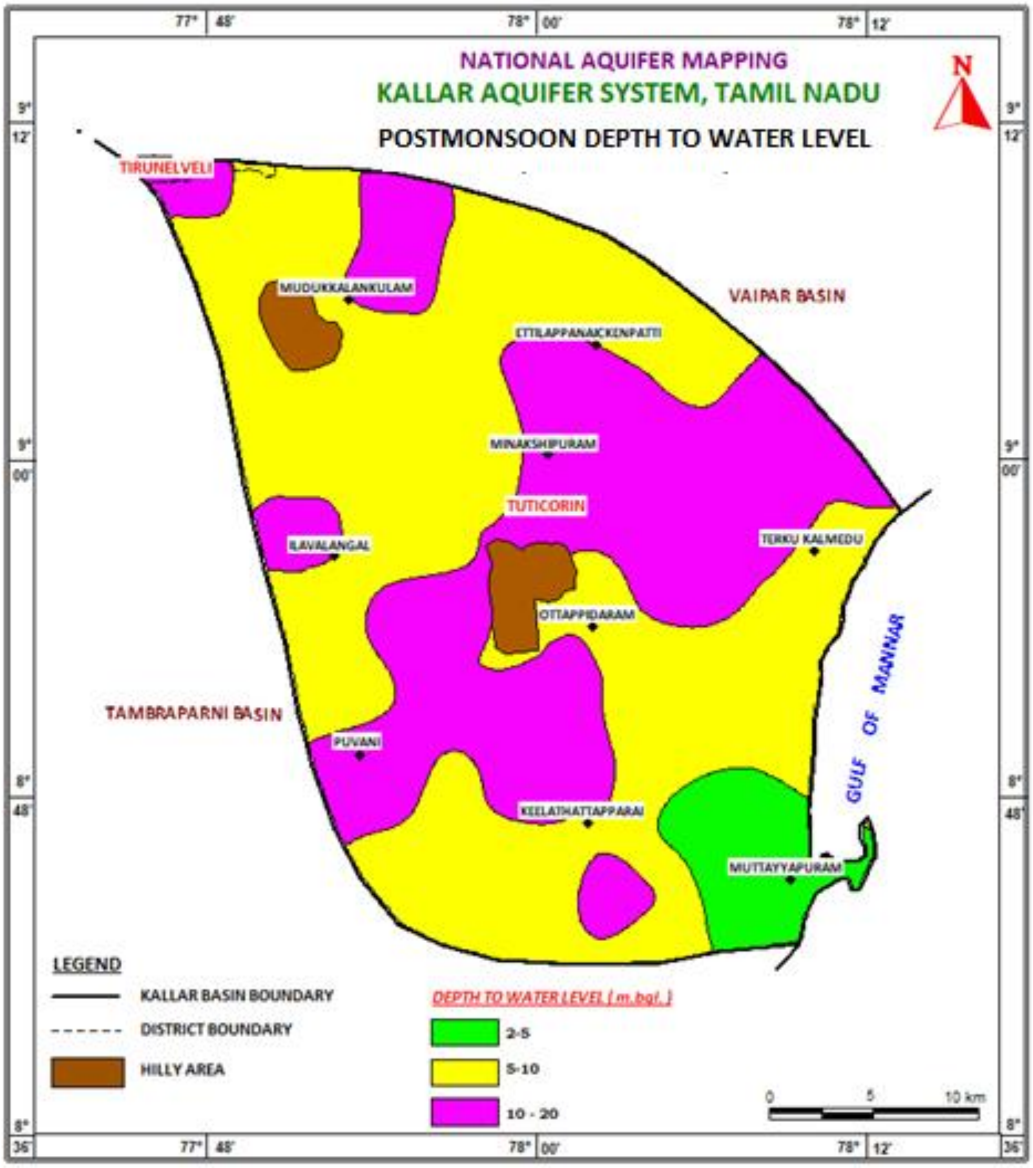


Figure 18. Depth to water level (Aquifer-I): Post-monsoon of the Kallar aquifer system

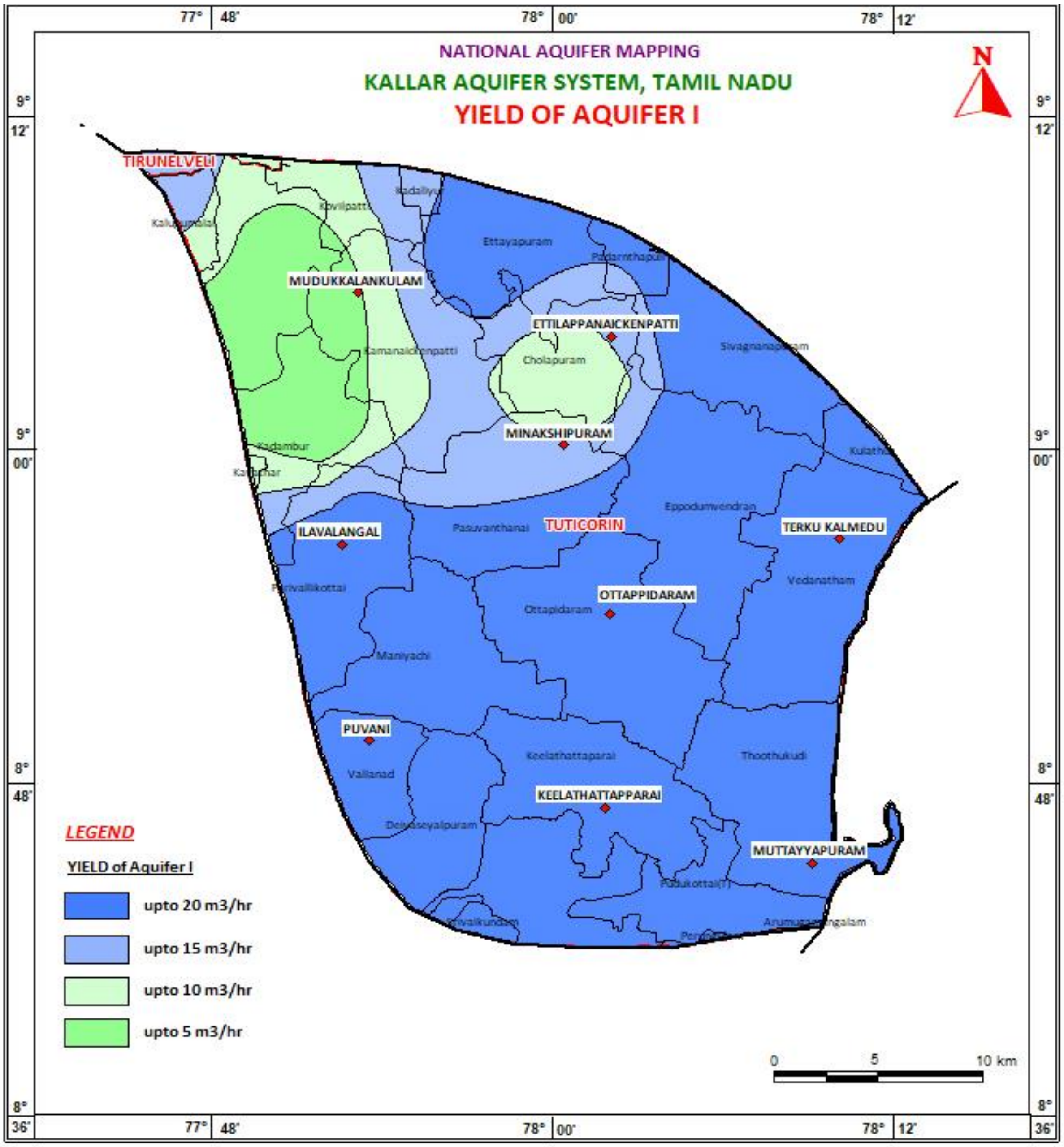


Figure 19: Yield of Aquifer I- Kallar aquifer system

YIELD POTENTIAL

HARD ROCK

Yield of Dug wells is 20 m3/hr in major swaths of SE and Central portion of the basin

NW flanks of the basin have lower yield ranging from 10-15 m3/hr

SEDIMENTARY

Yield > 20 m3/hr

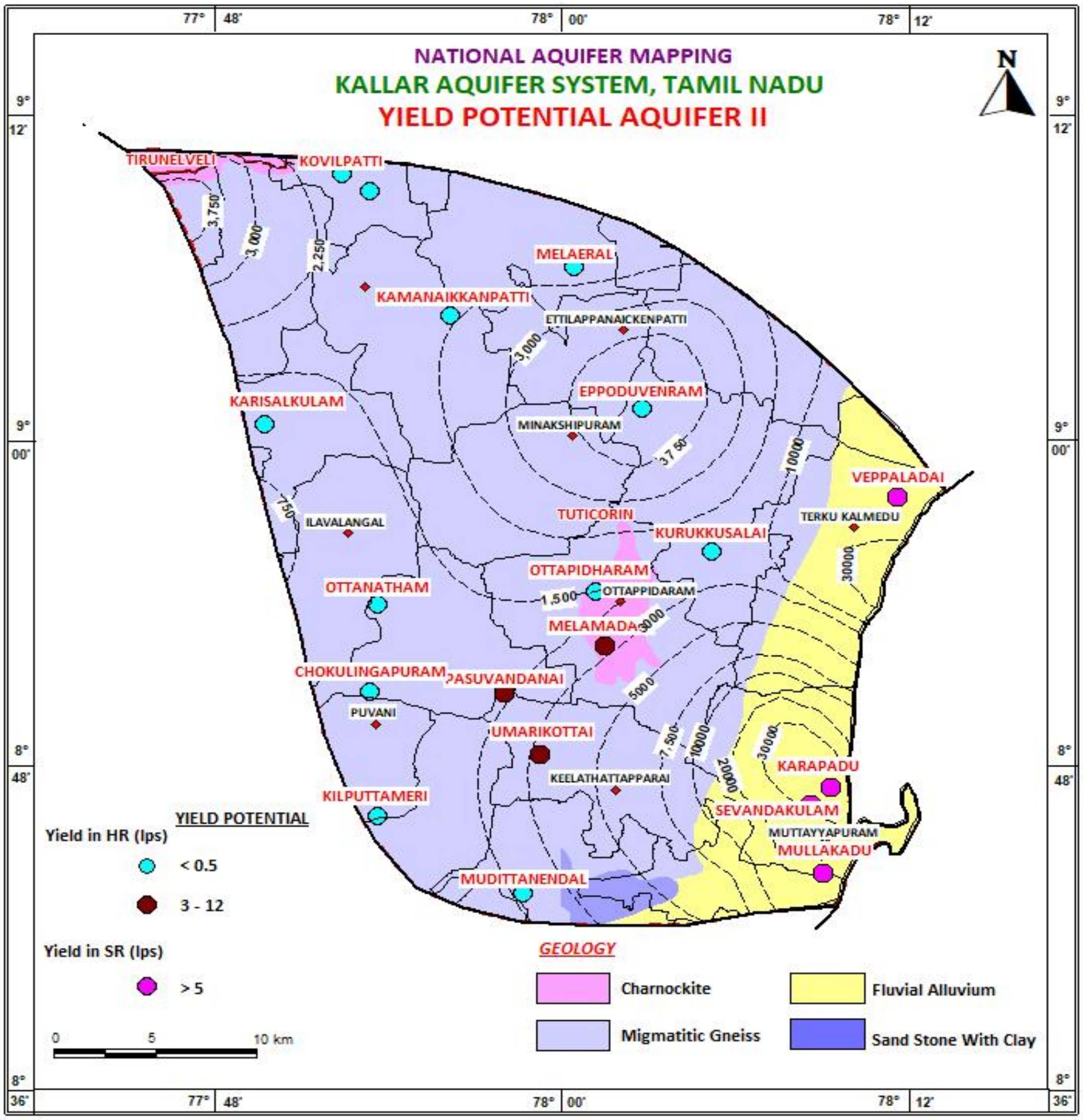


Figure 20. Yield of Aquifer II- Kallar aquifer system

Hard rock

- % of wells yield > 3lps : 20%
- High discharge wells located along NW-SE trending lineament
- Yield of bore wells : Highest discharge of 12 lps at Melamadom , 4 lps at Umarikottai,
- Major part having yield <0.5 lps (75 % of wells)

Sedimentary

- Discharge ranging between 6 to 22 lps. High TDS of >10000 mg/l making the formation water brine

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 range of various chemical constituents of ground water and the general water quality of groundwater in different aquifers in Kallar basin, Tamil Nadu. Some of the important parameters have been illustrated by distribution map of Electrical conductivity, Chloride, Nitrate and fluoride. 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 giveninFigure **21.**

Phreatic Aquifers have EC concentrations within the permissible limit generally ranging between 250-1000 µsiemens/cm except pockets in SE and NE swaths of the basin.

For Deeper Aquifer

Not potable at locations

- Ottapidaram
- Pasuvadanai and Vedanatham
- Pudukottai, Kilathattaparai and Kovilpatti

Aquifer Type	**Ec Values** µsiemens/cm	**No. of samples**	**% samples**
Aquifer I	250-1000	5	**71**
	2500-5000	2	29

Aquifer II	250-1000	5	17
	2500-5000	12	**41**
	5000-10000	6	21
	>10000	6	21

Sodium Adsorption Ratio And Soil Infiltration

The sodium adsorption ratio (SAR) is a measure of the amount of sodium relative to calcium and magnesium in water. It is the ratio of the Na concentration divided by the square root of one half of the Ca+ Mg concentration. It indicates the suitability of water for use in agricultural irrigation. High levels of sodium ions in water affect the permeability of soil and can lead to wataer

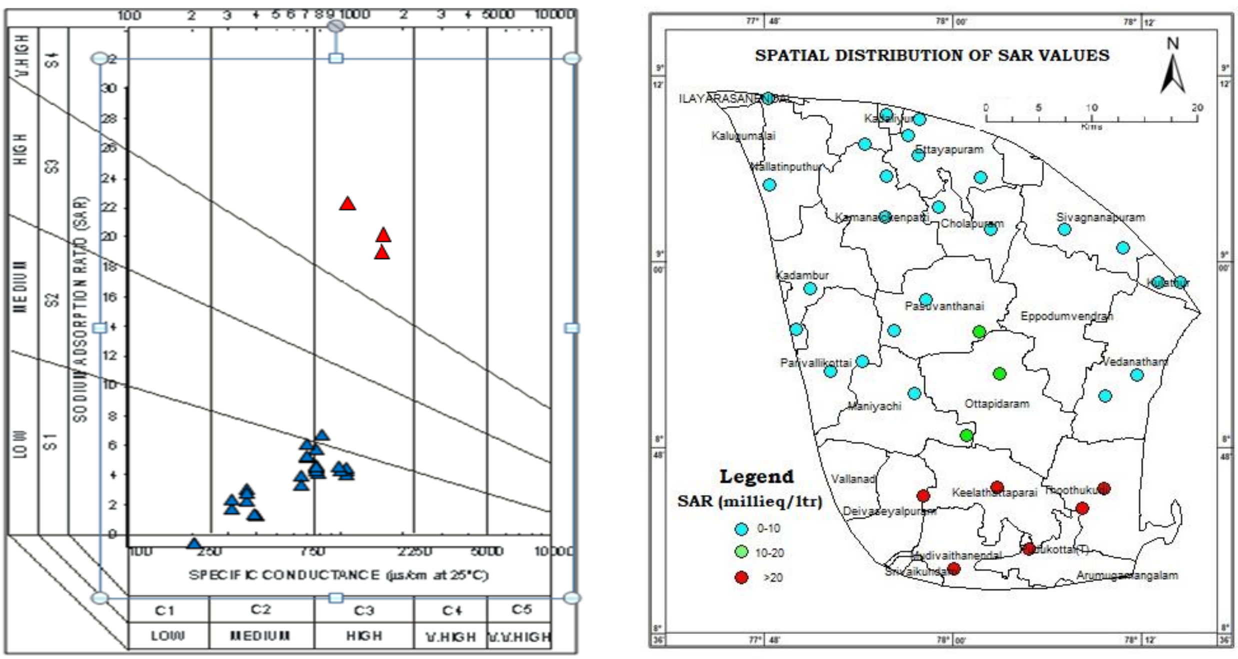
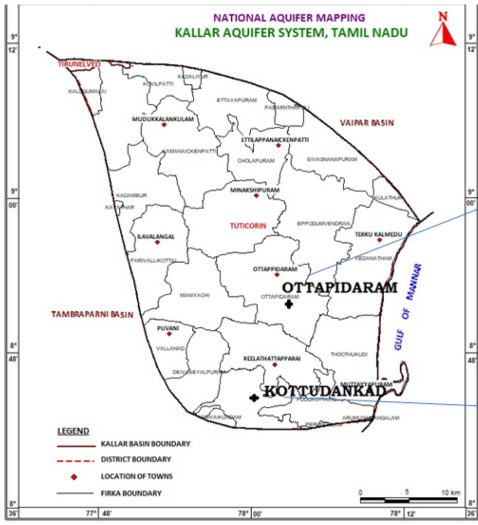


Figure 21: USSl diagram and Spatial distribution of SAR values

infiltration issues. From the figure it is evident that the areas of Ottapidaram, Pasuvadanai, Vedanatham, Pudukottai, Kilathattaparai and Kottudankadhave high SAR values and thus counter to any efforts of artificial recharge to augment the resources. Also the groundwater in these areas are unfit for irrigation purposes**.** Further the soil infiltrations test carried out at Kottudankad, the coastal area shows that the infiltration rate is quite low to the tune of 2.6 cm/hr which underlines the inference that the high SAR values observed are impediments to recharge of groundwater. **(Figures 21&22).**



Sl. No	Location	Infiltration Rate (cm/hr.)	Soil Type
1	Ottapidaram	9.8	Entisols
2	Kottudankadu	2.6	Alfisols

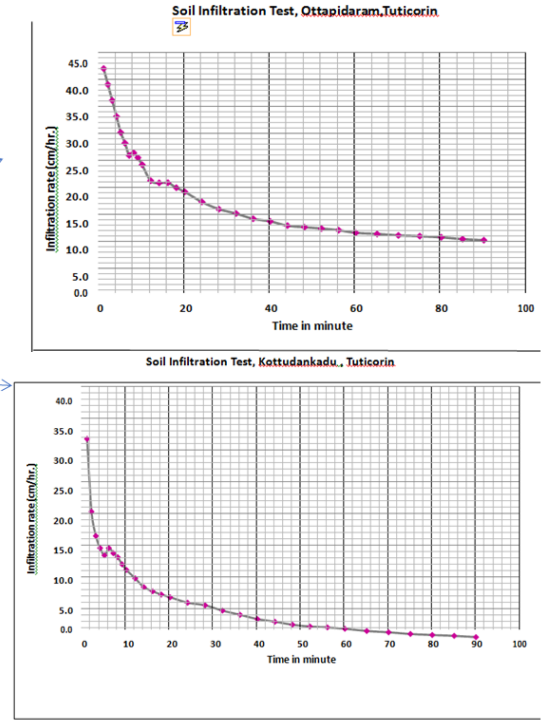


Figure 22 : Soil Infiltration tests in Kallar basin

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 250 to1000 mg/l. The distribution of chloride concentration in Aquifer-I is presented in **Figure 23**

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 solubility of most fluoride in groundwater. 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 generally within the permissible limit of 1.5 mg/l. The Kallar aquifer system have the phreatic unit with groundwater having fluoride concentrations between 0.3 to 0.8 mg/l. For the deeper aquifers the general range is between 0.35 to 1.33 mg/l. The hotspots in chloride concentration are found at two sites in Ottapidramfirka, 6 sites at Vedanathamfirka, keelathaparai and Sevanthakulam. **(Figure 24**).

3.3.3. Uranium

Dissolved uranium in groundwater at high concentrations is an emerging global threat to human and ecological health due to its relative radioactivity and chemical toxicity. Uranium can enter groundwater by geochemical reactions, natural deposition from minerals, mining, uranium ore processing, and spent fueldisposal. The analytical data of the groundwater samples of the Kallar Aquifer System indicate that the phreatic unit has uranium concentrations within the permissible limit ranging between 1.1 to 2.8 ppb. However hotspots are observed at Ottapidaram at 3 sites with concentration of 72, 73 and 75 ppb.

(Figure 25)

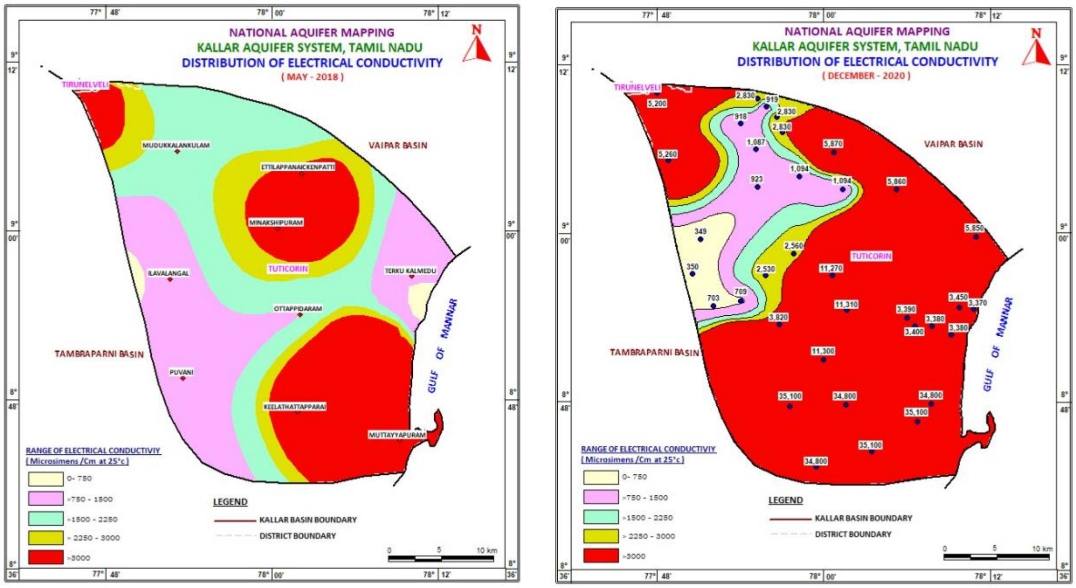


Figure 23: Distribution of EC in Aquifer I of the Kallar Aquifer system.

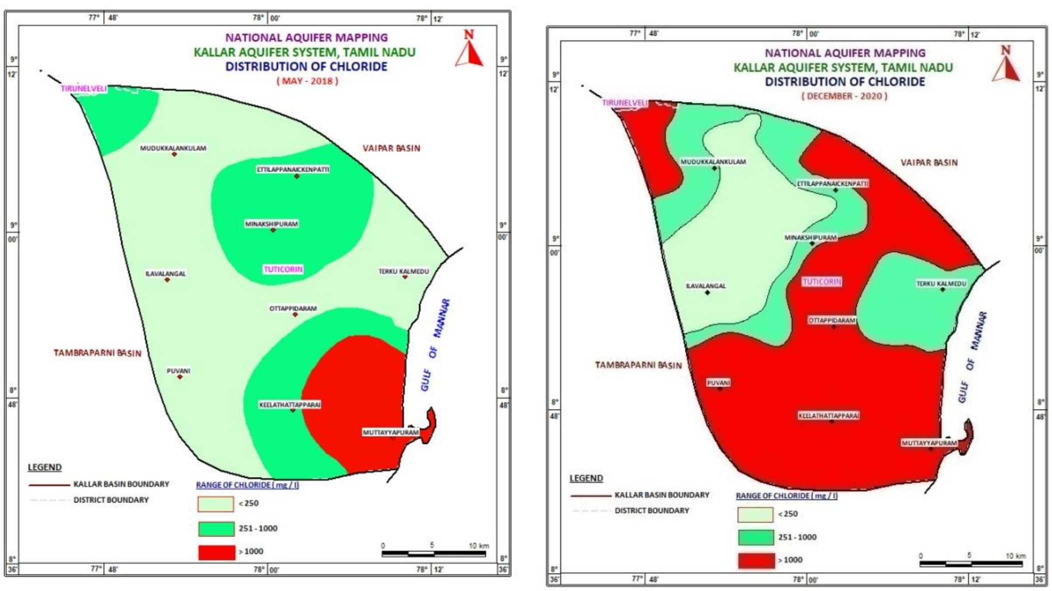


Figure 24: Distribution of chloride in Aquifer I of the Kallar Aquifer system.

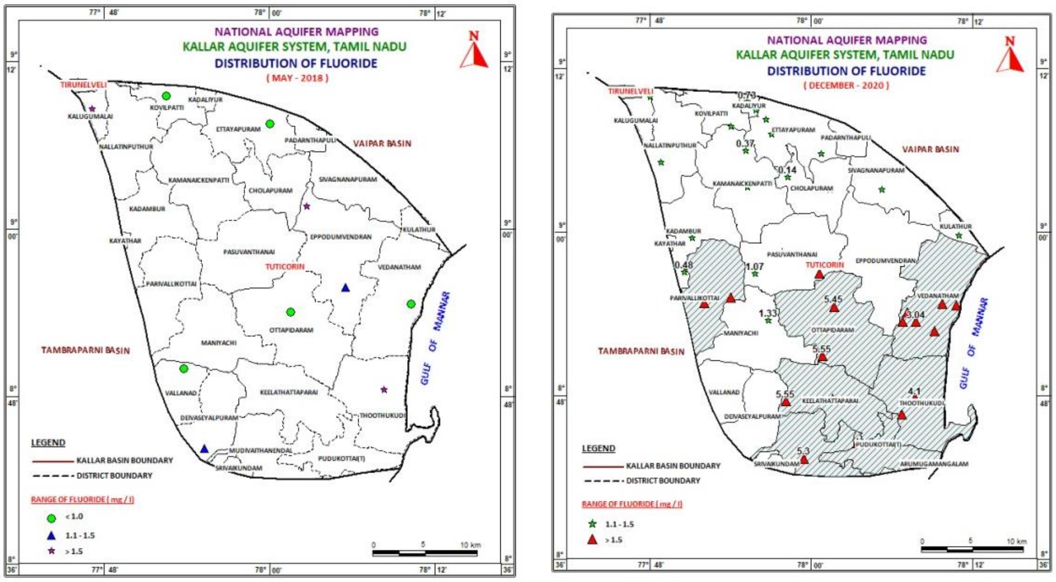


Figure 25: Distribution of Flouride in Aquifer I of the Kallar Aquifer system.

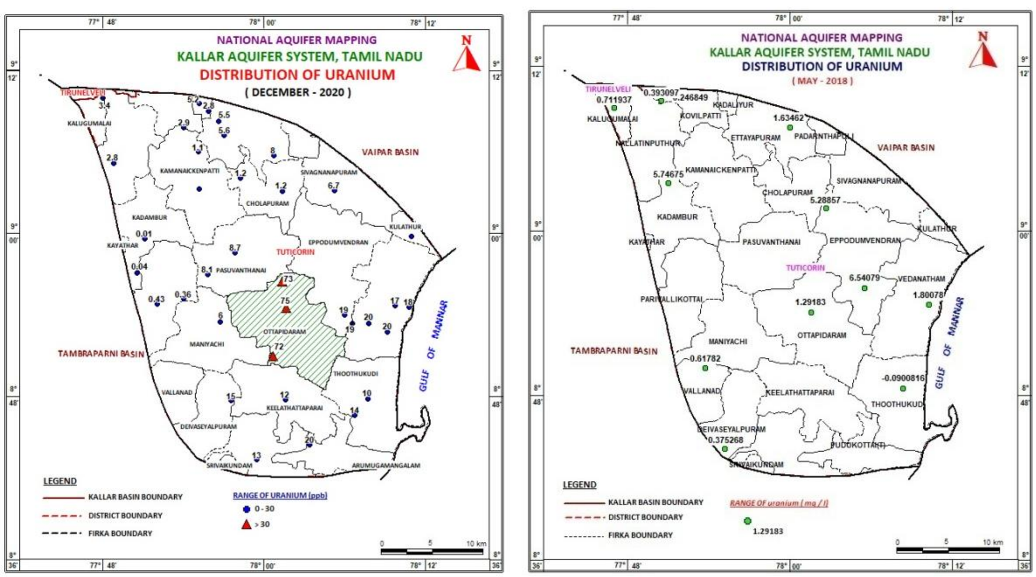


Figure 26: Distribution of Uranium in Aquifer I of the Kallar Aquifer system.

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 Kallar basin, TamilNaduis shown in **Figure27.** 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 47% of the groundwater samples are Sodium chloridetype, and 35% samples are calcium magnesiumchloride type. The spatial distributin of the hydrochemical facies shows that the Na cl type of water is evenly distributed throughout the basin indicating evapo crystallization process and introduction of marine aerosols into the groundwater system along the coastal area.

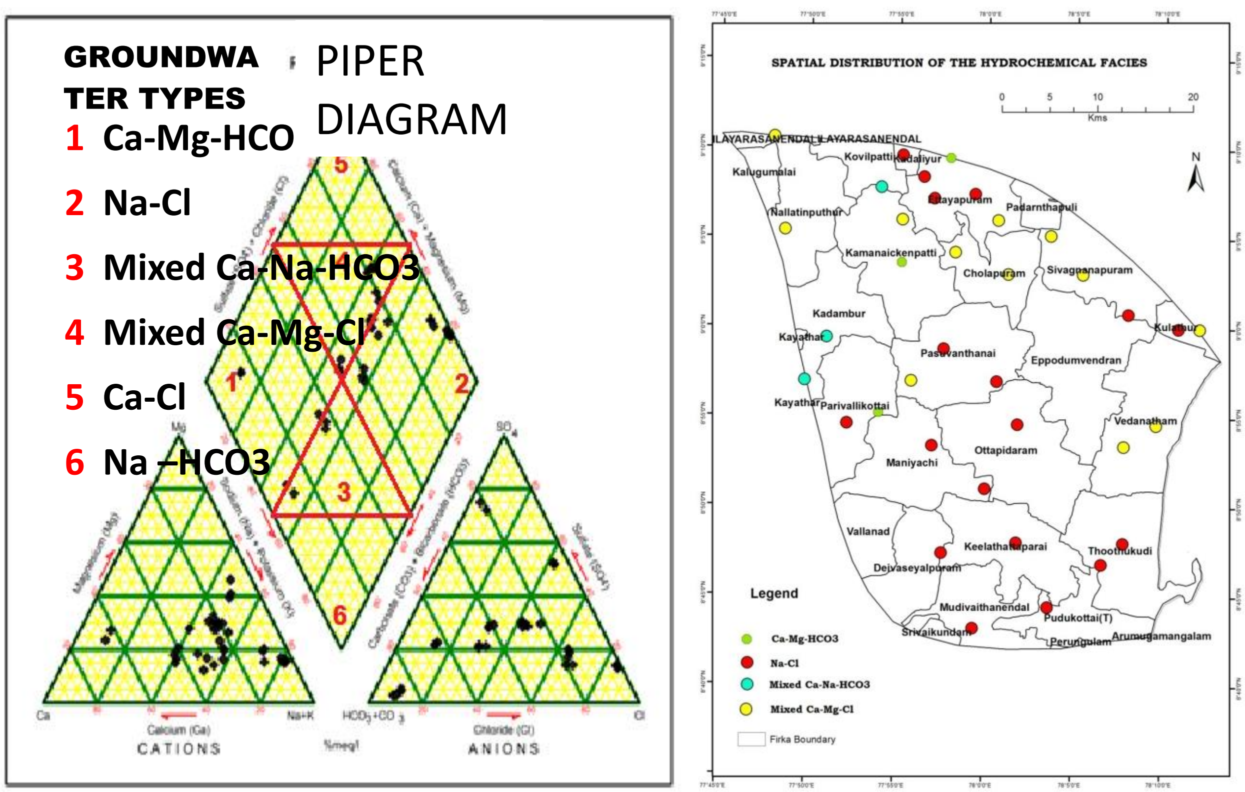


Figure 27: Groundwater facies distribution inthe Kallar Aquifer system.

Insitu salinity in the coastal aquifers

Salinity is a term used to describe the amount of salt present in a given water sample. It usually is referred to in terms of total dissolved solids measured in terms of milligrams of salts per liter (mg/L). Ground Water with a TDS concentration less than 1000 mg/L is considered as Fresh water. The somewhat arbitrary upper limit of fresh water is based on the suitability of water for human consumption. Ground water with TDS greater than 1000 mg/L is also used for domestic purpose in areas where water of lower TDS content is not available.

Generally ground water is classified as Fresh, Brackish, Saline and Brine depends on the TDS content of ground water . The Residium after fractional crystallization of NaCl (>35°Be) is called as Bitrine.

Classification of Ground water

Sl No	Category of Ground water	TDS (mg/L)
1	Fresh	<1000
2	Brackish	1000 -3000
3	Saline	1000 - 10000
4	**Brine**	>10000

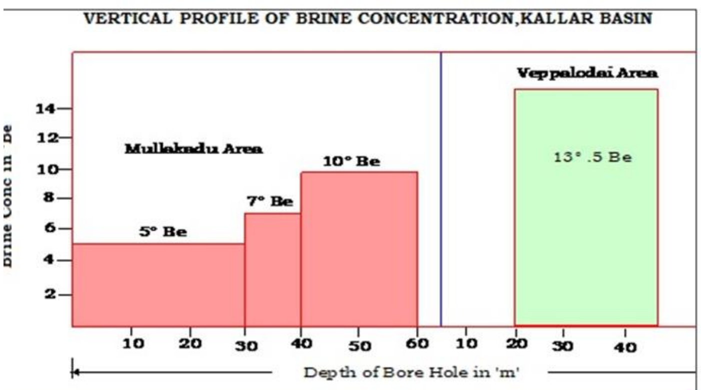
The Brine content of Ground water is generally expressed in terms of degree Baumine (°Be) and measured with hygrometer. The chemical composition of brine water in the coastal aquifers of Kallare Aquifer System and the brine concentrations are furnished in Tables below.

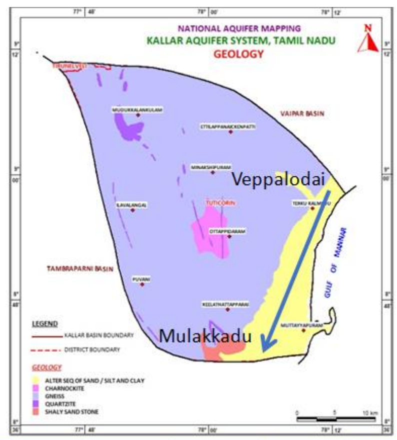
Chemical Composition of Brine water – Tuticorin District

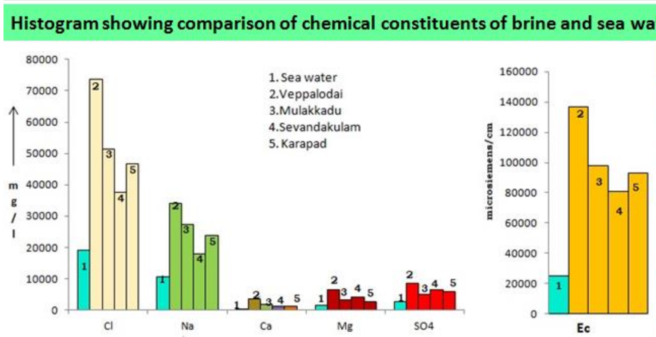
Location	Ec	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
Sevenda-kulam	80600	20500	1200	4256	17940	704	0	323	37432	6336	6	0.60
Mullakadu	97900	17500	1800	3162	27310	782	0	342	51402	4992	1.6	0.6
Karapad	93100	18000		2800	23920	1955	0	287	46797	6000	5	0.50
Veppalodai	136800	36000	3600	6566	34000	2346	0	262	73736	8400	2	0.40
Nagakanya-kapuram	1684	105	18	15	329	16	0	586	163	125	7	1.6

Brine concentrations of groundwater samples in the exploratory wells

Sl No	Location	District	Depth range (mbgl)	Brine concentration (°Be)	Remarks
1	Mullakadu	Tuticorin	0 – 30	5	Brine concentration increases with depth
2	Mullakadu	Tuticorin	30 – 40	7	
3	Mullakadu	Tuticorin	40 - 60	10	
4	Veppolodai	Tuticorin	22 - 45	13.5	







	Sea Water	Vepplodi	Mulakadu	Svndkulm	Karapad
Brine °Be	1	13.5	5	7	10
Cl (mg/l)	19000	73736	51402	37432	46794
Na	10500	34040	27310	17940	23920
Ca	410	3600	1800	1200	1300
Mg	1350	6566	3162	4256	2800
SO4	2700	8400	4992	6336	6000
Ec (µsiemens /cm)	25000	136800	97900	80600	93100

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 41lithologs 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 Kallar 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 28, 29** & the 3D aquifer disposition is shown in **Figure 30.**The exploratory wells details of CGWB wells are given in **Table 7**and the stratigraphic sequence is shown in **Table 8.**

Table7 :Exploratory wells details in Kallar Aquifer System

EW name	Latitude	Longitude	Total depth	Elevation
Kovilpatti	9.175	77.875	200	88.28
Tittankulam	9.173055556	77.8925	200	90.81
Chokulingapuram	8.845833333	77.8888889	200	78.315
Pasuvandanai	8.844444444	77.9666667	180	57.62
Melamadam	8.873611111	78.025	138	36.38
Umarikottai	8.806944444	77.9875	200	36.38
Kilputtameri	8.719444444	77.8236111	200	27.82
Mudittanendal	8.721666667	77.9777778	156	28.755
Eppoduvenram	9.02	78.046	200	35
Kamanaikkanpatti	9.07663	77.936	200	65
Karisalkulam	9.0063	77.787	200	76
kurukkusalai	8.9318	78.086	200	28
Melaeral	9.10663	78.00718	200	58
Ottanatham	8.899	77.8941	200	67
Ottapidharam	8.9068	78.0195	200	48
Veppaladai	8.965277778	78.2180556	47	1.22
Sevandakulam	8.775833333	78.1427778	46	4.215
Mullakadu	8.733333333	78.1505556	70	3.01
Karapadu	8.781666667	78.1608333	56	2.615

Table 8: The stratigraphic sequence of the exploratory wells in Kallar basin

EW name	Depth 1	Depth 2	Formation
Kovilpatti	0	0	Alluvium
Kovilpatti	0	0	Tertiary SST
Kovilpatti	0	0	Cretaceous Lst
Kovilpatti	0	98	Weathered
Kovilpatti	98	141	Fracture
Kovilpatti	141	200	Massive
Tittankulam	0	0	Alluvium
Tittankulam	0	0	Tertiary SST
Tittankulam	0	0	Cretaceous Lst

Tittankulam	0	7	Weathered
Tittankulam	7	180	Fracture
Tittankulam	180	200	Massive
Chokulingapuram	0	0	Alluvium
Chokulingapuram	0	0	Tertiary SST
Chokulingapuram	0	0	Cretaceous Lst
Chokulingapuram	0	62	Weathered
Chokulingapuram	62	135	Fracture
Chokulingapuram	135	200	Massive
Pasuvandanai	0	0	Alluvium
Pasuvandanai	0	0	Tertiary SST
Pasuvandanai	0	0	Cretaceous Lst
Pasuvandanai	0	13	Weathered
Pasuvandanai	13	28	Fracture
Pasuvandanai	28	180	Massive
Melamadam	0	0	Alluvium
Melamadam	0	0	Tertiary SST
Melamadam	0	0	Cretaceous Lst
Melamadam	0	33	Weathered
Melamadam	33	96.5	Fracture
Melamadam	96.5	138	Massive
Umarikottai	0	0	Alluvium
Umarikottai	0	0	Tertiary SST
Umarikottai	0	0	Cretaceous Lst
Umarikottai	0	12.5	Weathered
Umarikottai	12.5	24.5	Fracture
Umarikottai	24.5	200	Massive
Kilputtameri	0	0	Alluvium
Kilputtameri	0	0	Tertiary SST
Kilputtameri	0	0	Cretaceous Lst
Kilputtameri	0	68	Weathered
Kilputtameri	68	135	Fracture
Kilputtameri	177.9	200	Massive
Mudittanendal	0	0	Alluvium
Mudittanendal	0	0	Tertiary SST
Mudittanendal	0	0	Cretaceous Lst
Mudittanendal	0	13.2	Weathered
Mudittanendal	13.2	88	Fracture
Mudittanendal	88	156	Massive
Eppoduvenram	0	0	Alluvium
Eppoduvenram	0	0	Tertiary SST

Eppoduvenram	0	0	Cretaceous Lst
Eppoduvenram	0	71	Weathered
Eppoduvenram	71	72	Fracture
Eppoduvenram	72	200	Massive
Kamanaikkanpatti	0	0	Alluvium
Kamanaikkanpatti	0	0	Tertiary SST
Kamanaikkanpatti	0	0	Cretaceous Lst
Kamanaikkanpatti	0	36	Weathered
Kamanaikkanpatti	36	37	Fracture
Kamanaikkanpatti	37	200	Massive
Karisalkulam	0	0	Alluvium
Karisalkulam	0	0	Tertiary SST
Karisalkulam	0	0	Cretaceous Lst
Karisalkulam	0	39	Weathered
Karisalkulam	39	137	Fracture
Karisalkulam	137	200	Massive
kurukkusalai	0	0	Alluvium
kurukkusalai	0	0	Tertiary SST
kurukkusalai	0	0	Cretaceous Lst
kurukkusalai	0	33	Weathered
kurukkusalai	33	69	Fracture
kurukkusalai	69	200	Massive
Melaeral	0	0	Alluvium
Melaeral	0	0	Tertiary SST
Melaeral	0	0	Cretaceous Lst
Melaeral	0	138	Weathered
Melaeral	138	139	Fracture
Melaeral	139	200	Massive
Ottanatham	0	0	Alluvium
Ottanatham	0	0	Tertiary SST
Ottanatham	0	0	Cretaceous Lst
Ottanatham	0	42	Weathered
Ottanatham	42	194	Fracture
Ottanatham	194	200	Massive
Ottapidharam	0	0	Alluvium
Ottapidharam	0	0	Tertiary SST
Ottapidharam	0	0	Cretaceous Lst
Ottapidharam	0	38	Weathered
Ottapidharam	38	40	Fracture
Ottapidharam	40	200	Massive
Veppaladai	0	7	Alluvium

Veppaladai	7	47	Tertiary SST
Veppaladai	47	47	Cretaceous Lst
Veppaladai	47	47	Weathered
Veppaladai	47	47	Fracture
Veppaladai	47	47	Massive
Sevandakulam	0	14	Alluvium
Sevandakulam	14	45	Tertiary SST
Sevandakulam	45	45	Cretaceous Lst
Sevandakulam	45	46	Weathered
Sevandakulam	46	46	Fracture
Sevandakulam	46	46	Massive
Mullakadu	0	12	Alluvium
Mullakadu	12	61	Tertiary SST
Mullakadu	61	67	Cretaceous Lst
Mullakadu	67	70	Weathered
Mullakadu	70	70	Fracture
Mullakadu	70	70	Massive
Karapadu	0	8	Alluvium
Karapadu	8	32	Tertiary SST
Karapadu	32	53	Cretaceous Lst
Karapadu	53	56	Weathered
Karapadu	56	56	Fracture
Karapadu	56	56	Massive

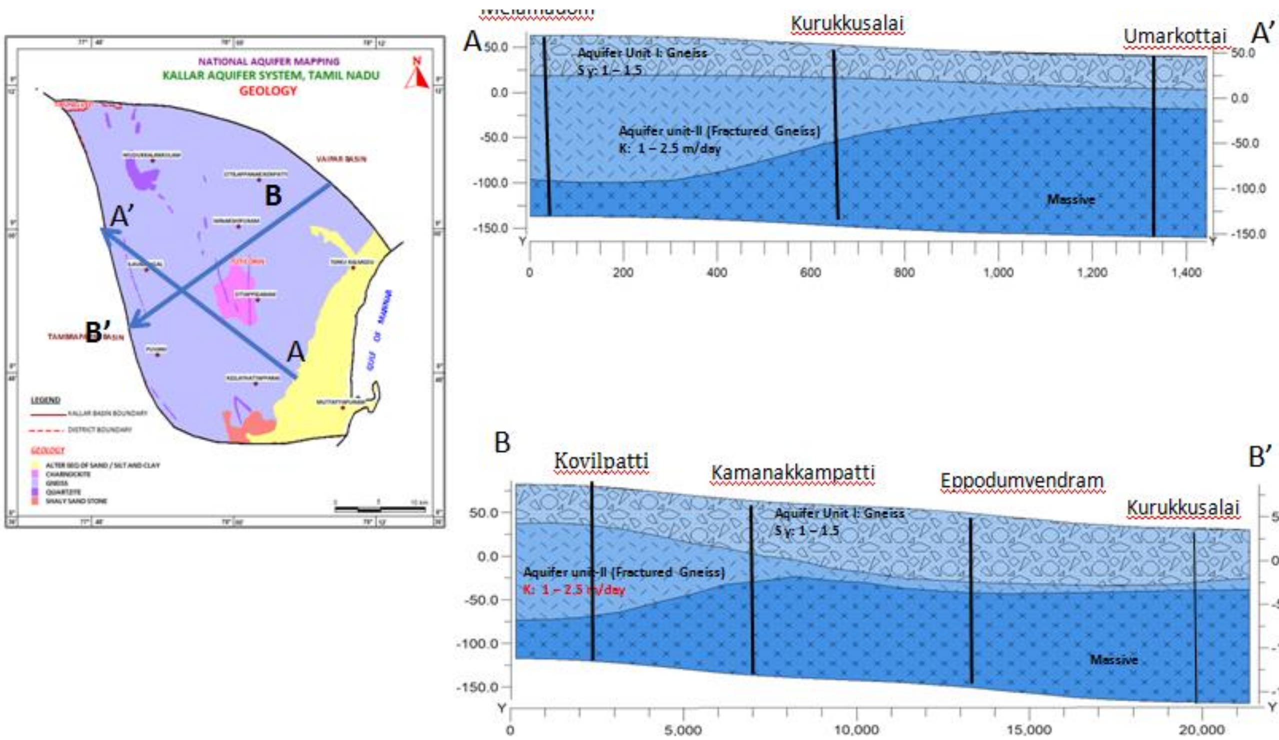


Figure 28: 2D Aquifer Disposition along A-A' (NE-SW direction in Hard rock terrain of the Kallar Aquifer system).

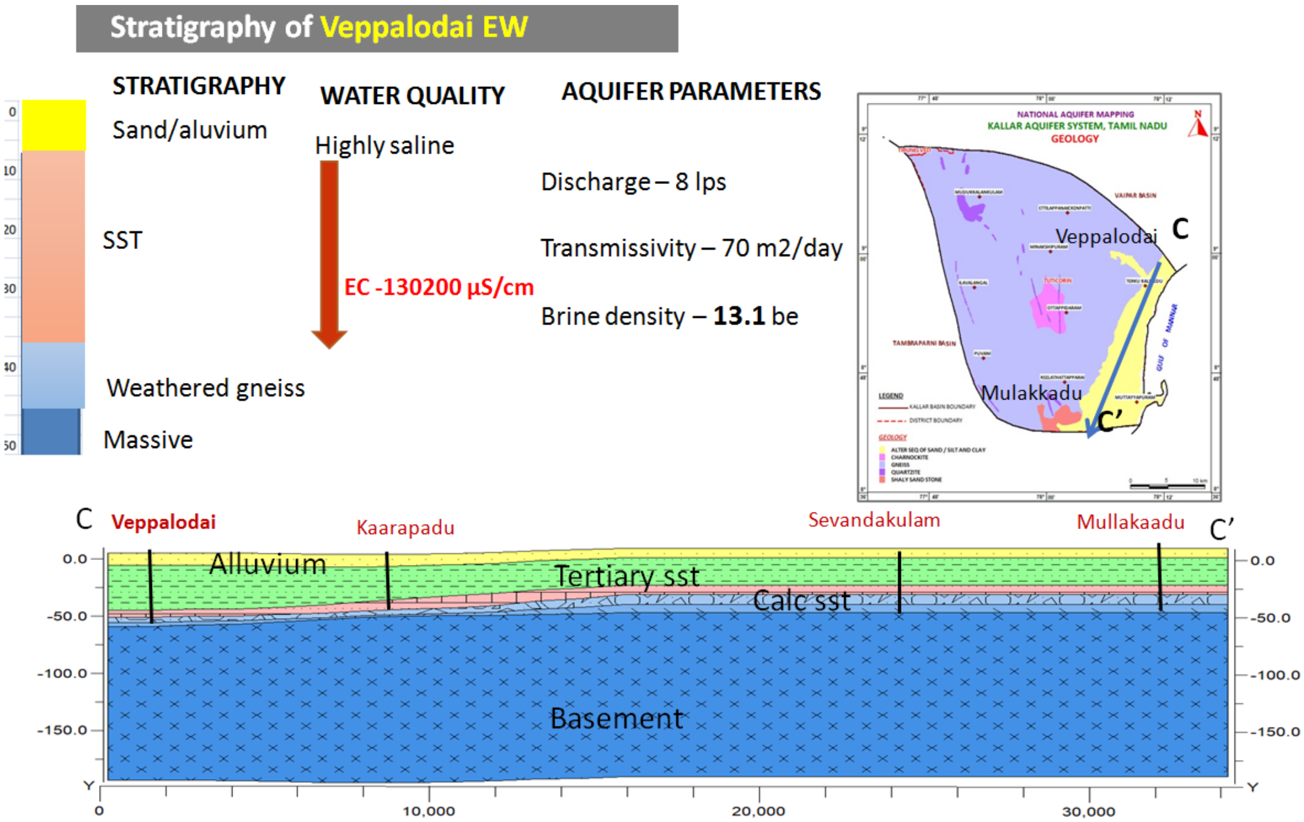


Figure 29: 2D Aquifer Disposition along D-D' (NW-SE direction of the Kallar Aquifer system).

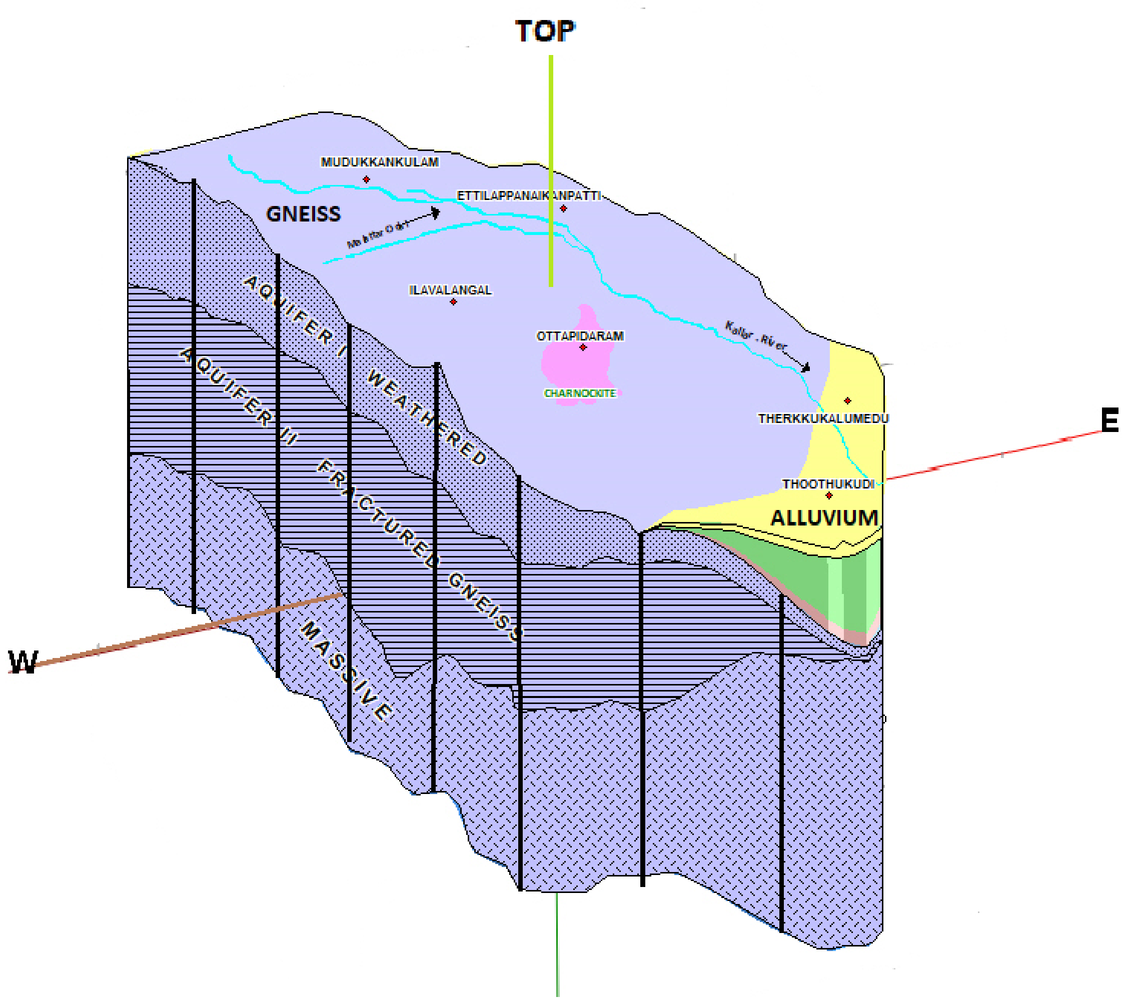


Figure 30: 3D Aquifer Disposition of the Kallar Aquifer system.

4.0. GROUNDWATER RESOURCES:

The dynamic groundwater resources have been estimated as on 2020 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 2020, jointly by State PWD of Tamil Nadu and CGWB, to arrive at the total resources available in the study basin. A total of 19Firkas 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 2020 is arrived at 16214 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 2020 is arrived at 6190Ham, and the stage of groundwater extraction is worked out at 38%.**(Figure 31).**

4.3. Stage of Groundwater Extraction and Categorization:

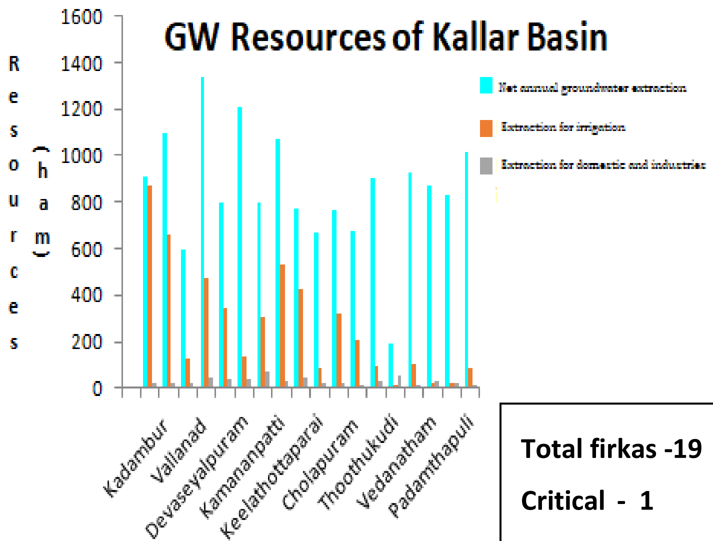
The stage of groundwater extraction is defined by

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 19 firkas of the aquifer system and arrived at 35%.

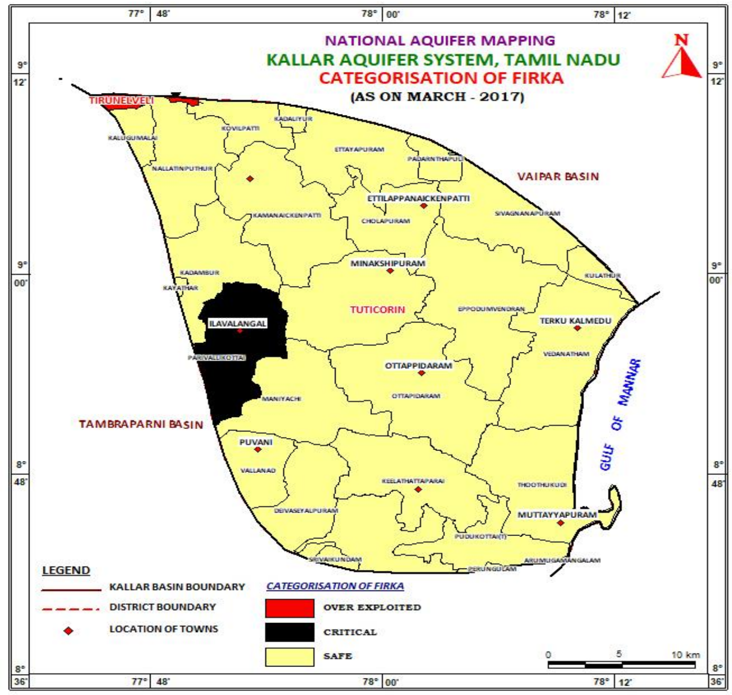
Basin	**Area**	**Net Annual Extractable GW Resources (ha m)**	**Extraction for Irrigation**	**Extraction for Domestic and industrial uses**	**All uses**	**SGWE %**
Kallar	1691	6190	5499	624	6123	35



Total firkas -19

Critical - 1

Safe -18



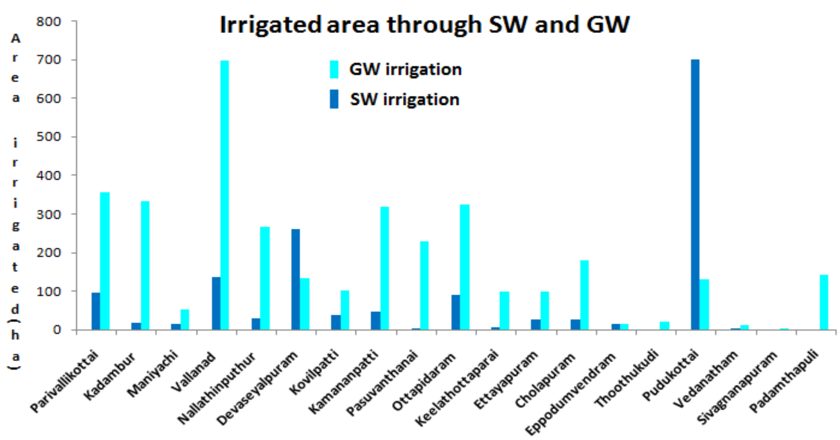


Figure 31. Categorisation of assessment units in Kallar aquifer system

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

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 32.**

VES data of 70 locations in the basin have been interpreted to verify the existence of structurally weak zones and to decipher the depth of weathered rocks. 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 9)** are detailed

- 3 high yielding wells located along the NW-SE trending lineaments namelyMelamadom (43.2 m3/hr), Ummarikotai (14.4 m3/hr) and Pasuvandanai (10.8 m3/hr)
- The high yielding wellshave more sets of fractures as observed from the drilling data
- 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
- Stressedfirkas 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.

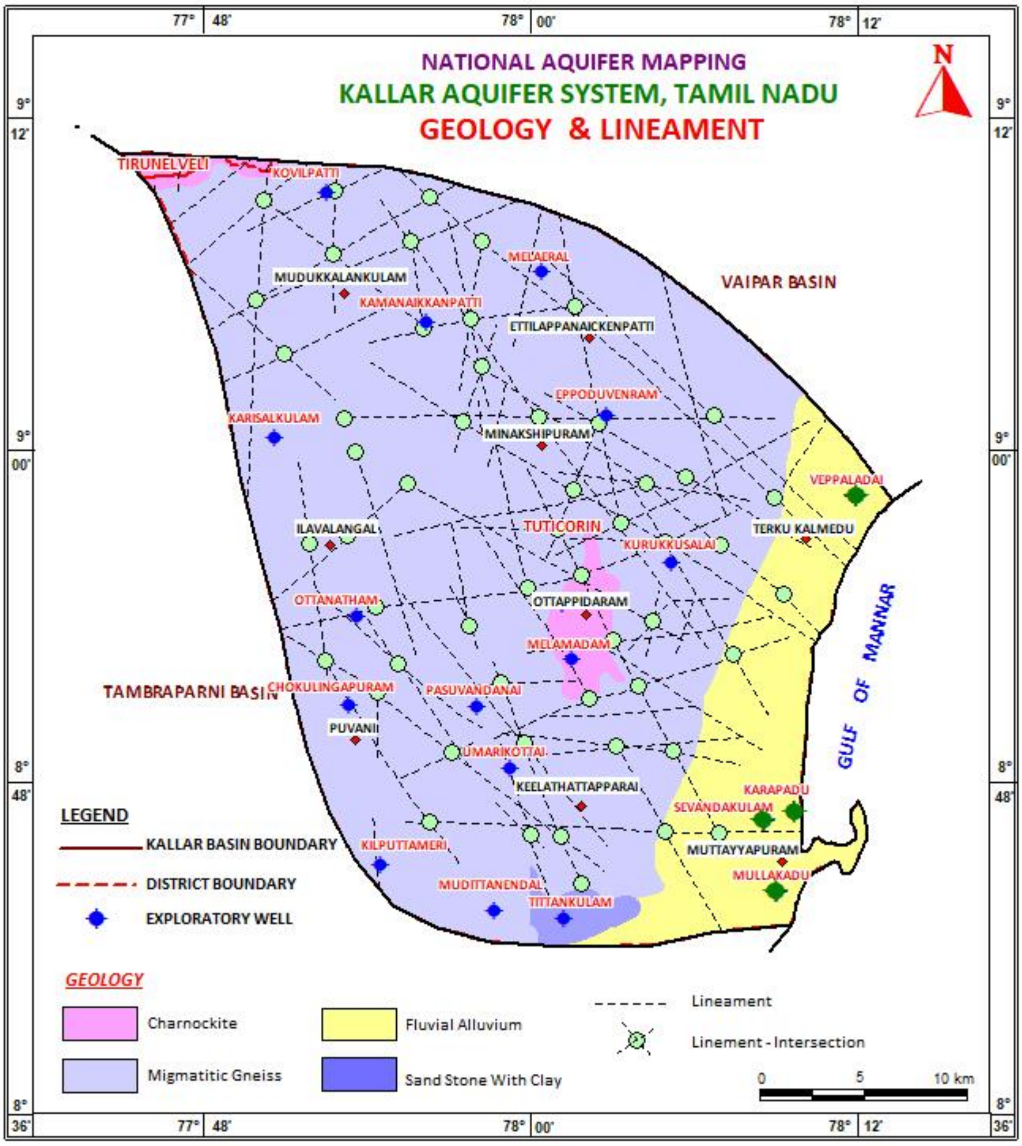


Figure 32. Groundwater potential zones in Kallar aquifer system

Table9 : Exploratory well analysed to interpret groundwater potential zones

Village	Aquifer_1_Top_mbgl	Aquifer_1_Bottom_mbgl	Aquifer_1_Thickness_m	Aquifer_2_Top_mbgl	Aquifer_2_Bottom_mbgl	Aquifer_2_Thickness_m	Potential zone /Granular zone/Fracture zone 1 From (mbgl)	Potential zone /Granular zone/Fracture zone 1 To (mbgl)	Q_lpm
Eppodumvenran (GHSS) EW	0	17.5	18	17.5	72.5	55	72	72.5	30
KALANKARIYANPATTI EW	0	21	21	21	35	14	34	35	1
KAMANAYAKKANPATTI	0	6	6	6	37	31			15
KARISALKULAM EW	0	16.2	16	16.2	137	120	136	136.5	30
KURUKKUSALAI	0	23	23	23	34	11	32.36	34	11
MELAERAL	0	12	12	12	139.04	127	138.04	139.04	30
OTTANATHAM EW	0	14	14	14	40	26	38.98	39.9	72
SEKKARAKUDI	0	6	6	6	61	55	55	61	26
SILLANGULAM	0	7	7						
SIVAGNANAPURAM (G. HS. S) OW	0	6	6	6	27.74	21.7	26.74	27.74	201
SIVAGNANAPURAM EW	0	5.5	6	5.5	42.98	37.4	41.98	42.98	5
Kailaspuram (Kilakottai) OW	0	8	8						
M.Pudur (A.Thiyakurichi) EW	0	17	17						
Meignanapuram EW	0	37	37	37	47.5	10.5	47	47.5	12
Parivilikottai (Malaipatti) EW	0	9	9						
Pudukottai (Panchalamkurichi A/C) EW	0	17	17	17	90.5	73.5	90	90.5	8
Thimmarajapuram EW	0	17	17	17	83.5	66.5	83	83.5	12

5.0. GROUNDWATER RELATED ISSUES:

The Kallar aquifer system is predominantly occupied by hard rocks which warrants cautious groundwater development strategy because of the below mentioned issues

- Poor Yielding aquifers
- Drying up of shallow wells
- Decrease in yield of borewells affecting the sustainability of abstraction structures
- Insitu Salinity

- Limited scope for Artificial Recharge Schemes in the saline tracts of the basin
- Limited freshwater availability in sedimentary areas occuring as floating lenses makes the coastal tract vulnerable for water quality changes
- Pollution of groundwater due to industrial effluents

Groundwater is extensively utilized for irrigation in the entire basin area for the past two decades, especially in Parivallikottai ,Kadambur , Ottapidaram, Nallathimpudur, Kamananpatti, Kovilpattiand Thoothukudifirkas - out of the 19firkas of the study area. The aquifer system is also stressed due to the insitu salinity observed all along the southern flanks of the basin which further is a major impediment to the availability of sustainable groundwater resources.

5.1.Geographical distribution & Resource Availability:

In the study area northern and northwestern part is reeling under over development. Over all out of 19firkas of the study areas, Parivallikotaifirka is categorized under critical stage.Alsofirkas which are under groundwater stressed conditions owing to geological constraint are Kadambur, Ottapidaram, Nallathimpudur, Kammanaickanpatti and Pasuvanthanai. These areas have low groundwater potential and hence have minimal development. Groundwater extraction is to the tune of 62, 65, 51, 55 and 48%.

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 the Gneiss group of rock with marginal occurrence of Charnockite and sedimentaries distribute along the centre and southern part of the basin respectively. Fractures in the gneissic terrain occur within 40-60 m bgl and the frequency of occurrence of fractures is promising in this depth zone. In some area the fracture system existupto the depth of 197 m bgl, but the frequency of occurrence of fractures in these depth ranges is low. Comparatively Charnockite are more massive than granitic gneiss and it occupies only around 3% of the study basin. The interesting inference made after the analysis of the yields from bore well is that the high yield wells are located along these geologic divide ie the gneiss and the charnockite divide.

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 Kallar aquifer system. Kallar Aquifer Systemhas only one firka, Parivalikottaifirka which is categorised as critical. The Net availability of the resource is 162.14 MCM. The total ground water demand for the basin is 62 MCM. Based on the supply of groundwater resources, the stage of groundwater development of the basin is 38.18%. The stage of groundwater development for the critical firka, Parivalikottai is 95.55%

(based on 2020). To bring safe groundwater development, 25% of groundwater development should be added to the groundwater system in the stressefirka also customized management strategies are adopted in the safe firkas wherein the stage of development is 50% and above to have a long term sustainability of the groundwater resources. Therefore, supply side intervention is proposed in the basin through groundwater augmentation plan as sufficient uncommitted surplus runoff of 182ha m 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 132 ha m.. The annual uncommitted runoff is 182 ha m and73% 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. 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 31 check dams, 49 Nala bunds and 94 recharge shafts are proposed in the stressedfirkas 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 13 MCM. The stage of groundwater development would reduce and this increase in resources would translate to enhanced irrigation potential.

Water Conservation Plan

A total number of 234 recharge ponds covering an area of 20.4 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 10 MCM. The deatails provided in the table below

Firka	**Tank area proposed for desiltation (sq km)**	**Water recharged (MCM)**
Parivalikottai	2	1
Kadambur	2.5	1.25
Ottapidaram	5.56	2.78
Nallathimpudur	1.478	0.739
Kamananpatti	4.94	2.47
Kovilpatti	3.94	1.97
Total	**20.4**	**10**

6.2 Demand side Management Plan

Demand side management can be accomplished through modification in the irrigation practice. It is recommended to modify the conventional practices in irrigation 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 and this would save 2.08 MCM of water annually if the practice is adopted for 30%f irrigated area and the water saved will be (**Figure 33**).3.5 MCM if the practice is adopted in 50% of the irrigated area.

Table

Firka	Parvalikottai	Kadambur	Otapidaram	Nalathimputhur	Kamananpati	Kovilpatti
Geographical Area	119.1 sq km	130	137	96.4	104	85.98
Area Identified for recharge (sq km)	89.325	97.5	102.75	72	78	63.75
Monsoon Rainfall (m)	0.433	0. 584	0.433	0.605	0.591	0.561
Stage of groundwater extraction (%)	95.52	61	65	51	55	50
Uncommitted surface runoff/ flow (MCM)	7.68	10.18	8.58	6.19	6.71	5.55
Weathered zone for recharge (MCM)	14.28	14.04	45.96	11.52	12.48	10.32
Quantity rechargeable	2.25	2.54	2.5	1.75	2.15	1.80
Effect on water level	1.28	1.3	1.2	1.0	1.2	1.3

ARTIFICIAL RECHARGE /CONSERVATION MEASURES		
Artificial Recharge Structures Proposed	Masonry Check dams Nala bunds Recharge shafts RRR ponds with Recharge shafts	31 49 94 75
Water Conservation Measure	Recharge Ponds	235
Tentative total cost of the project (Rs.)		15 Cr
Vol. of unsaturated zone available for Recharge (upto 8 m bgl)		108 MCM
Uncommitted Surplus runoff		45 MCM
Harnessable runoff		22.5 MCM
Expected recharge		13 MCM
Additional Potential created for 13 MCM of recharge		
Expected outcome	Arrest Decline in Groundwater levels (or) Increase pumping hours (or) ...nabi...	

SUPPLY SIDE INTERVENTION

AR Structures proposedin Critical/vulnerablefirkas

Masonry Check dam : 31

Nala bund : 49

Recharge shafts : 94

RRR ponds with

Recharge shafts : 75

Farm ponds : 235

Water Recharged :13 MCM

DEMAND SIDE INTERVENTION

Change in Irrigation Pattern

Paddy : SRI

Sugarcane : Flooding to MI

Banana : Flooding to MI

Scenario : 1 30% Area : Change in irrigation pattern

Water saved : 2.08 MCM

Stage of Development scaled down provided irrigated area remains constant.

Scenario : 2 50% Area :

Change in irrigation pattern

Water saved : 3.5 MCM

Groundwater augmentation + Change in irrigation pattern area way forward for ensuring sustainabilityof groundwater resources of the basin.

AQUIFER MANAGEMENT PLAN FOR KALLAR BASIN

Firka	Parvalikottai	Kadambur	Otapidaram	Nalathimputhur	Kamananpati	Kovilpatti
Geographical Area	119.1 sq km	130	137	96.4	104	85.98
Area Identified for recharge (sq km)	89.325	97.5	102.75	72	78	63.75
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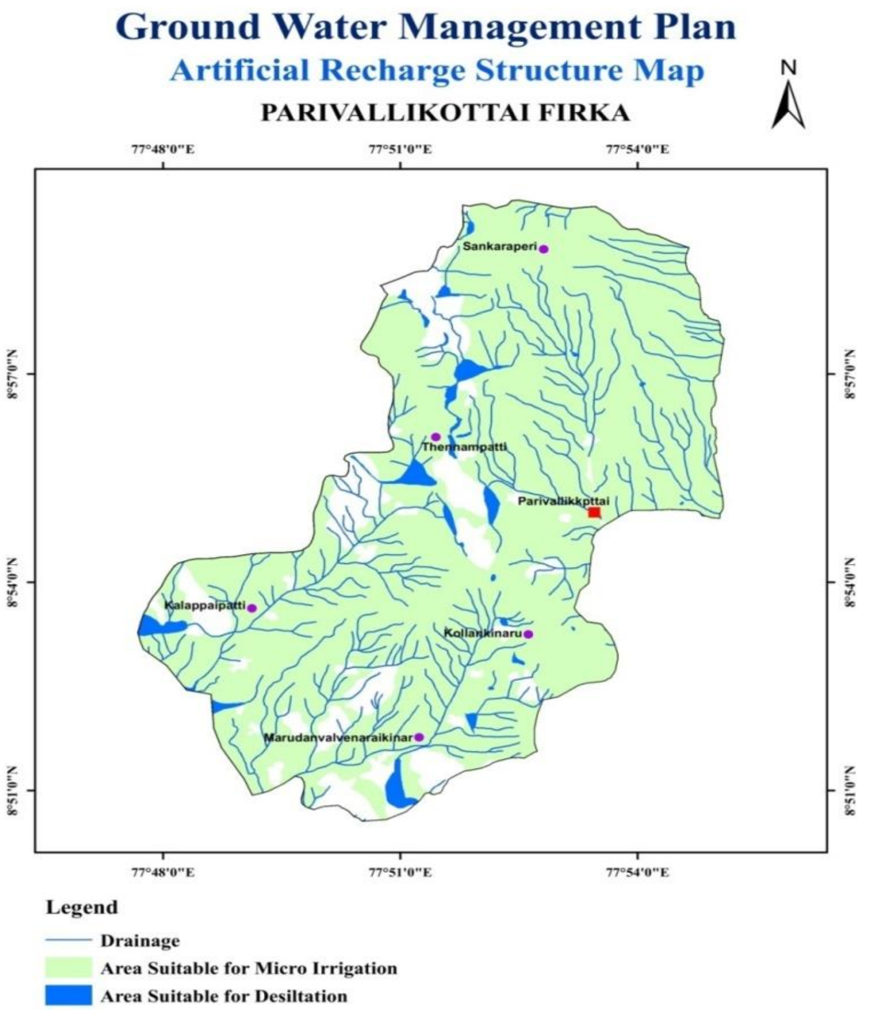

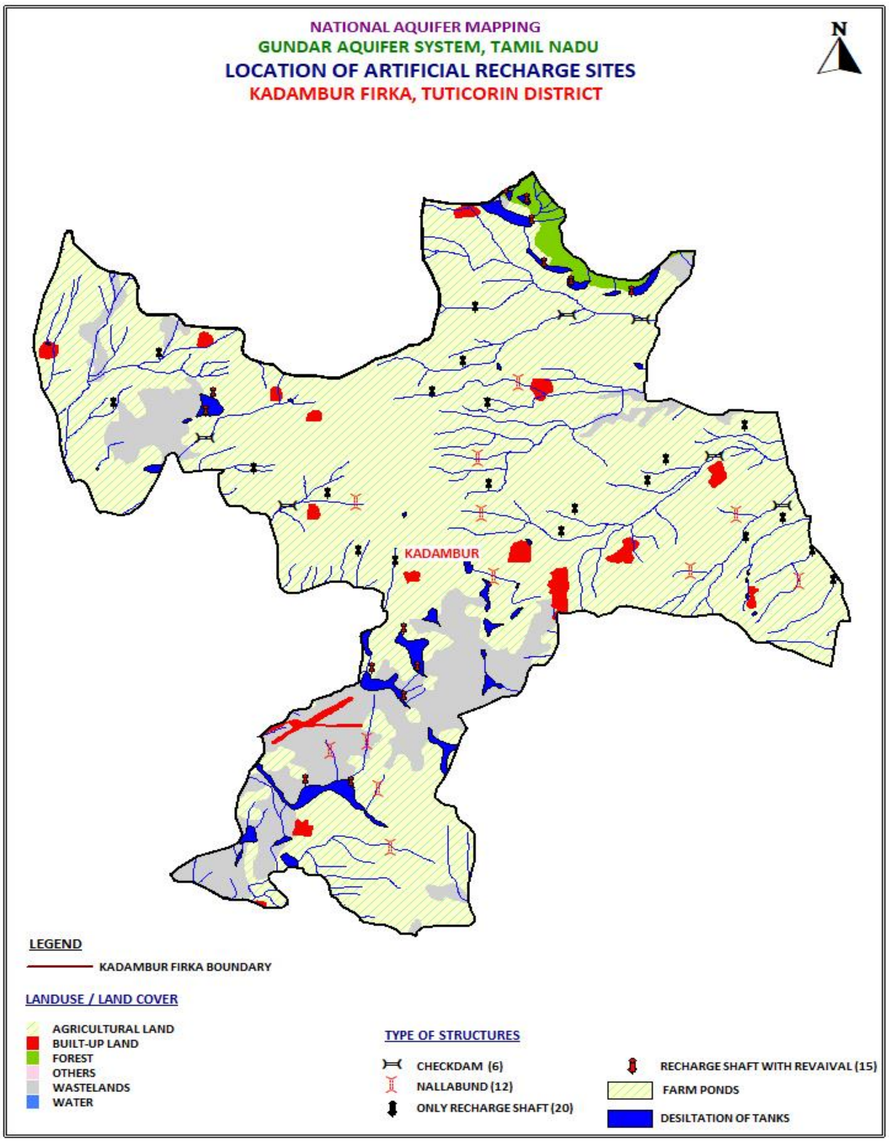
NATIONAL AQUIFER MAPPING
GUNDAR AQUIFER SYSTEM, TAMIL NADU
LOCATION OF ARTIFICIAL RECHARGE SITES
KADAMBUR FIRKA, TUTICORIN DISTRICT
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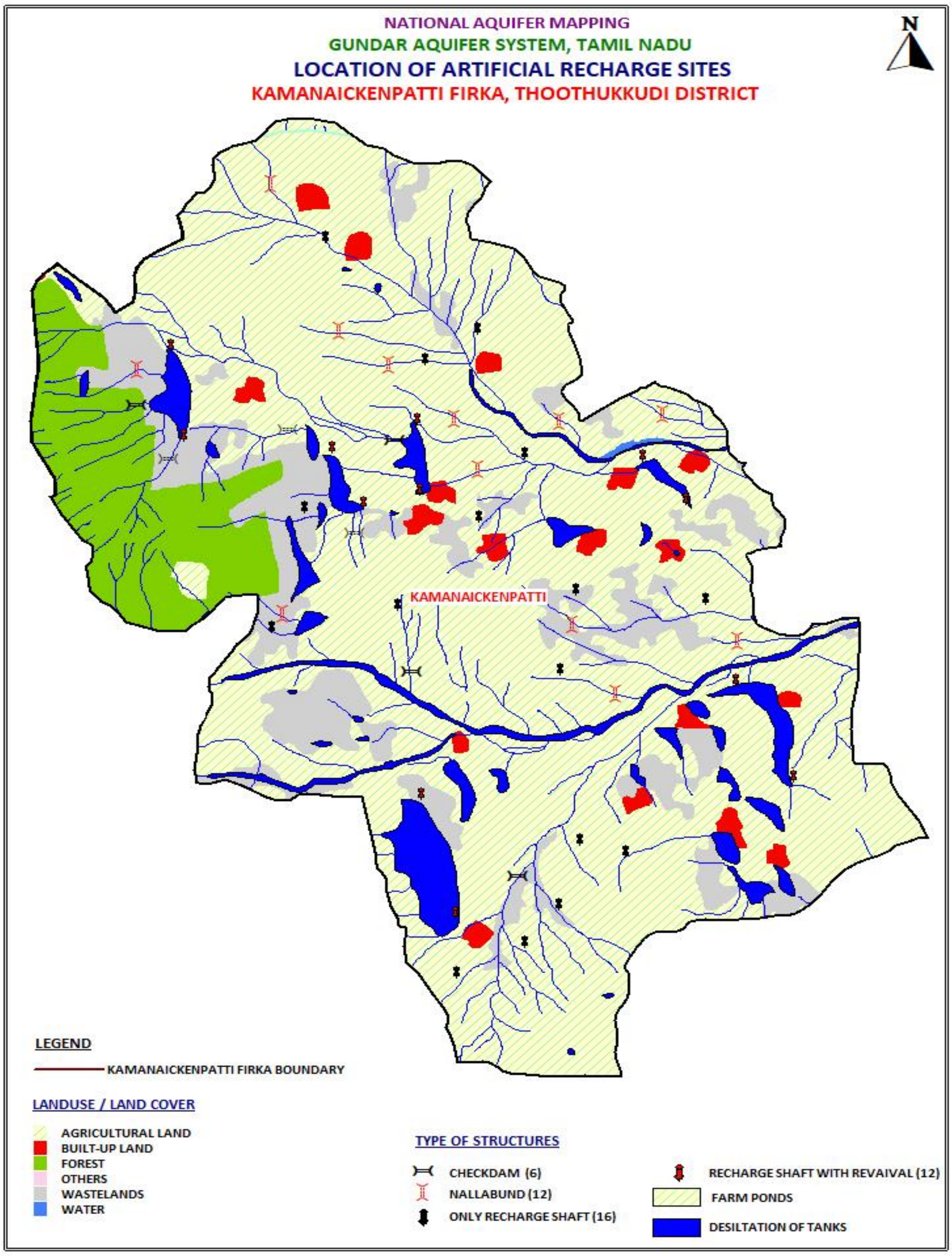
KADAMBUR
LEGEND
KADAMBUR FIRKA BOUNDARY
LANDUSE / LAND COVER
AGRICULTURAL LAND
BUILT-UP LAND
FOREST
OTHERS
WASTELANDS
WATER
TYPE OF STRUCTURES
CHECKDAM (6)
NALLABUND (12)
ONLY RECHARGE SHAFT (20)
RECHARGE SHAFT WITH REVAIVAL (15)
FARM PONDS
DESILTATION OF TANKS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KAMANAICKENPATTI FIRKA BOUNDARY
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RECHARGE SHAFT WITH REVAIVAL (12)
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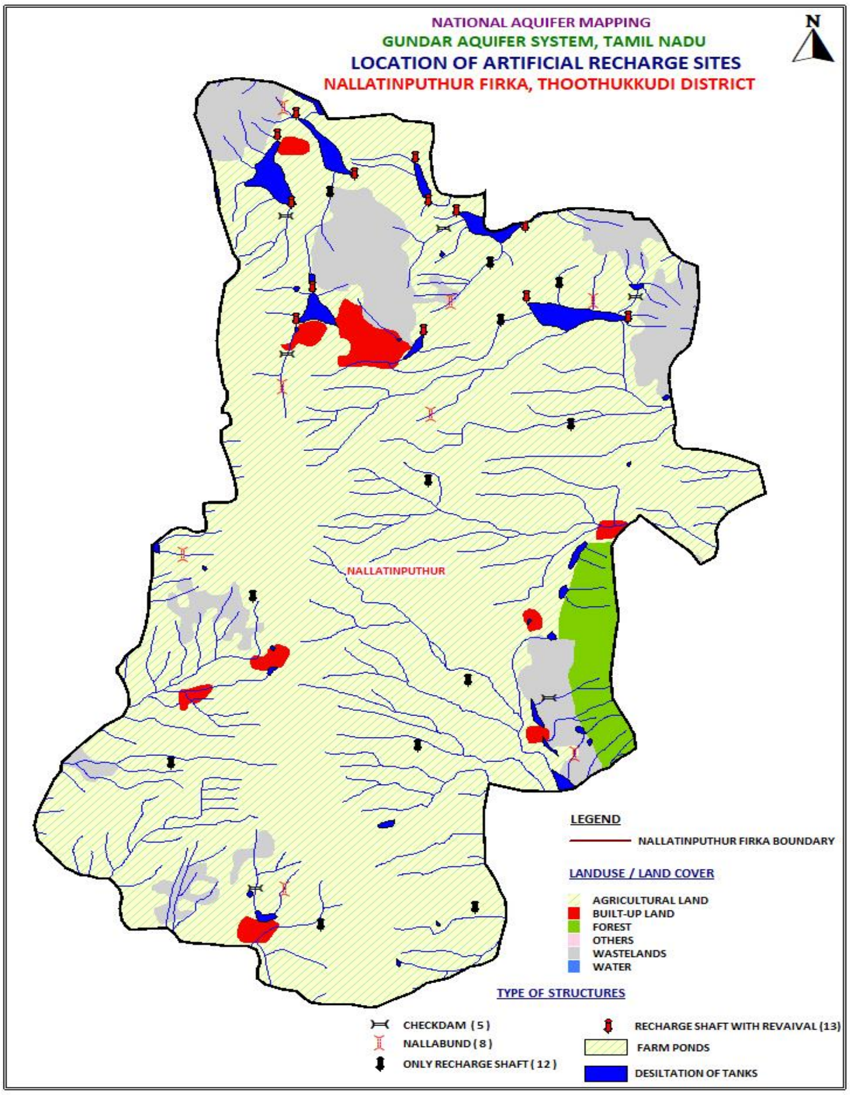
DESILTATION OF TANKS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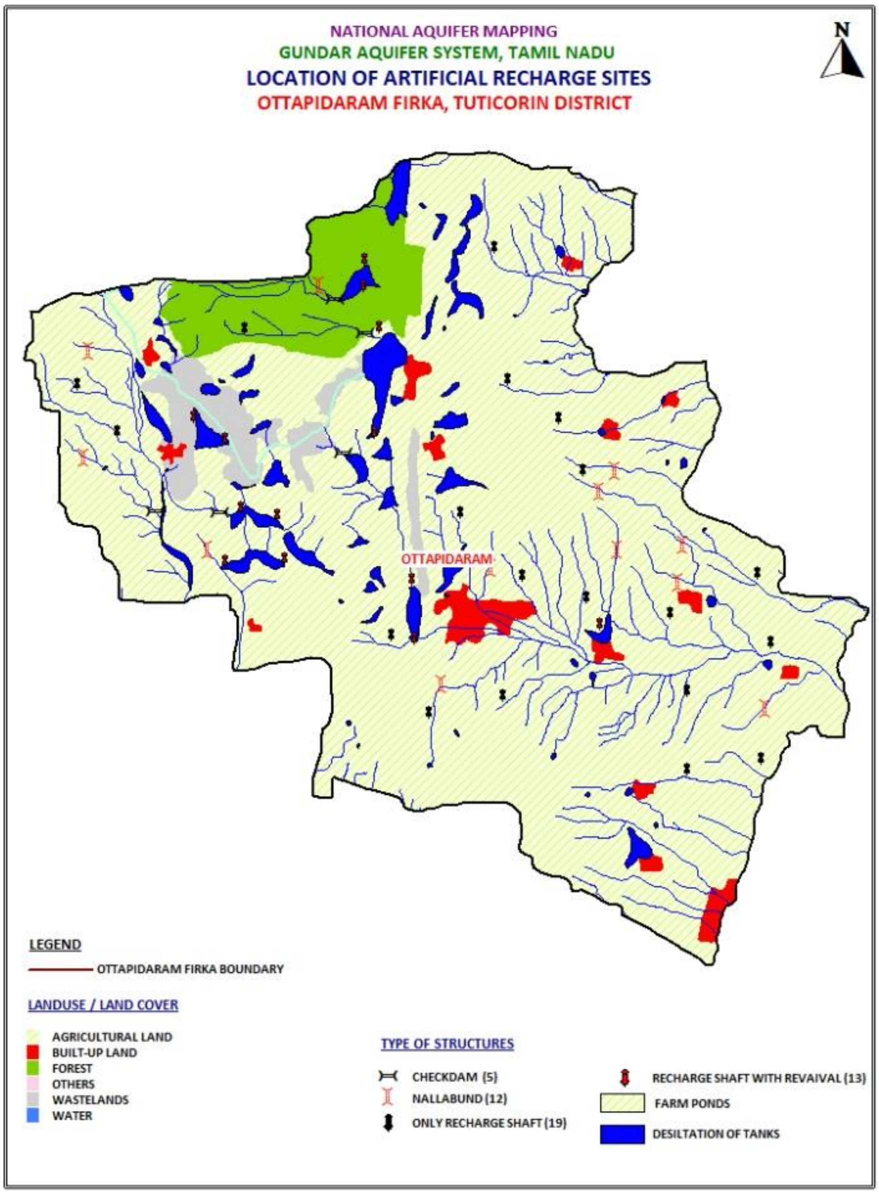
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DESILTATION OF TANKS

Development and management of Coastal Aquifers in the Kallar Aquifer Syatem

The coastal aquifers of Tuticorin area needs careful management practices in view of the vulnerable sea water instruction problems and limited scope for artificial recharge schemes in saline tracts.

Necessary measures for regulating the exploitation of ground water may be implemented particularly in Teri sand aquifer area and fresh water bearing Tertiary sandstone areas along the coast has to be notified.

Modeling of coastal aquifers is needed for varies stress conditions in view of brine and fresh water development is very high in the region.

Intensive monitoring of ground water levels and water quality is to be taken up to monitor the movement of fresh and saline water interface.

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

District: MADURAI						
Sl no.	Block Name	Firka Name	Category	Latitude	Longitude	Proposed AR Structure
1		Nallathimputhur	Safe	9.1727	77.8114	NB
2		Nallathimputhur	Safe	9.1433	77.8532	NB
3		Nallathimputhur	Safe	9.1301	77.8113	NB
4		Nallathimputhur	Safe	9.1431	77.8340	NB
5		Nallathimputhur	Safe	9.1260	77.8313	NB
6		Nallathimputhur	Safe	9.0537	77.8115	NB
7		Nallathimputhur	Safe	9.0743	77.8507	NB
8		Nallathimputhur	Safe	9.1046	77.7978	NB
9		Nallathimputhur	Safe	9.1561	77.8119	Nalla_CD
10		Nallathimputhur	Safe	9.1438	77.8590	Nalla_CD
11		Nallathimputhur	Safe	9.0537	77.8078	Nalla_CD
12		Nallathimputhur	Safe	9.0826	77.8473	Nalla_CD
13		Nallathimputhur	Safe	9.1541	77.8332	Nalla_CD
14		Nallathimputhur	Safe	9.1350	77.8120	Nalla_CD
15		Nallathimputhur	Safe	9.1676	77.8105	RRR_Nalla
16		Nallathimputhur	Safe	9.1574	77.8125	RRR_Nalla
17		Nallathimputhur	Safe	9.1708	77.8132	RRR_Nalla
18		Nallathimputhur	Safe	9.1617	77.8210	RRR_Nalla
19		Nallathimputhur	Safe	9.1642	77.8292	RRR_Nalla
20		Nallathimputhur	Safe	9.1576	77.8309	RRR_Nalla
21		Nallathimputhur	Safe	9.1561	77.8347	RRR_Nalla
22		Nallathimputhur	Safe	9.1550	77.8439	RRR_Nalla

23		Nallathimputhur	Safe	9.1538	77.8440	RRR_Nalla
24		Nallathimputhur	Safe	9.1429	77.8443	RRR_Nalla
25		Nallathimputhur	Safe	9.1398	77.8579	RRR_Nalla
26		Nallathimputhur	Safe	9.1443	77.8153	RRR_Nalla
27		Nallathimputhur	Safe	9.1396	77.8132	RRR_Nalla
28		Nallathimputhur	Safe	9.1378	77.8303	RRR_Nalla
29		Nallathimputhur	Safe	9.1589	77.8177	RS nalla
30		Nallathimputhur	Safe	9.1482	77.8393	RS nalla
31		Nallathimputhur	Safe	9.1449	77.8487	RS nalla
32		Nallathimputhur	Safe	9.1394	77.8408	RS nalla
33		Nallathimputhur	Safe	9.1235	77.8502	RS nalla
34		Nallathimputhur	Safe	9.0846	77.8364	RS nalla
35		Nallathimputhur	Safe	9.0973	77.8072	RS nalla
36		Nallathimputhur	Safe	9.0745	77.8296	RS nalla
37		Nallathimputhur	Safe	9.1149	77.8309	RS nalla
38		Nallathimputhur	Safe	9.0500	77.8372	RS nalla
39		Nallathimputhur	Safe	9.0719	77.7963	RS nalla
40		Nallathimputhur	Safe	9.0473	77.8164	RS nalla
41		Kadambur	Safe	9.0239	77.8009	CD
42		Kadambur	Safe	9.0472	77.8645	CD
43		Kadambur	Safe	9.0465	77.8775	CD
44		Kadambur	Safe	9.0205	77.8904	CD
45		Kadambur	Safe	9.0111	77.8155	CD
46		Kadambur	Safe	9.0112	77.9023	CD
47		Kadambur	Safe	8.9575	77.8312	NB
48		Kadambur	Safe	8.9666	77.8292	NB
49		Kadambur	Safe	8.9647	77.8228	NB
50		Kadambur	Safe	8.9465	77.8334	NB
51		Kadambur	Safe	8.9976	77.8515	NB

52		Kadambur	Safe	9.0095	77.8942	NB
53		Kadambur	Safe	8.9986	77.8861	NB
54		Kadambur	Safe	8.9967	77.9051	NB
55		Kadambur	Safe	9.0344	77.8559	NB
56		Kadambur	Safe	9.0200	77.8486	NB
57		Kadambur	Safe	9.0096	77.8495	NB
58		Kadambur	Safe	9.0117	77.8273	NB
59		Kadambur	Safe	9.0314	77.8023	RRR
60		Kadambur	Safe	9.0281	77.8009	RRR
61		Kadambur	Safe	9.0507	77.8758	RRR
62		Kadambur	Safe	9.0525	77.8652	RRR
63		Kadambur	Safe	9.0561	77.8603	RRR
64		Kadambur	Safe	9.0681	77.8489	RRR
65		Kadambur	Safe	9.0642	77.8581	RRR
66		Kadambur	Safe	9.0682	77.8574	RRR
67		Kadambur	Safe	9.0698	77.8536	RRR
68		Kadambur	Safe	8.9794	77.8302	RRR
69		Kadambur	Safe	8.9739	77.8357	RRR
70		Kadambur	Safe	8.9796	77.8380	RRR
71		Kadambur	Safe	8.9868	77.8357	RRR
72		Kadambur	Safe	8.9581	77.8185	RRR
73		Kadambur	Safe	8.9577	77.8265	RRR
74		Kadambur	Safe	9.0316	77.8407	RS
75		Kadambur	Safe	9.0375	77.8462	RS
76		Kadambur	Safe	9.0477	77.8482	RS
77		Kadambur	Safe	9.0390	77.7927	RS
78		Kadambur	Safe	9.0295	77.7847	RS
79		Kadambur	Safe	9.0123	77.8223	RS
80		Kadambur	Safe	9.0050	77.8633	RS

81		Kadambur	Safe	9.0094	77.8658	RS
82		Kadambur	Safe	9.0149	77.8785	RS
83		Kadambur	Safe	9.0189	77.8817	RS
84		Kadambur	Safe	9.0251	77.8956	RS
85		Kadambur	Safe	9.0041	77.8959	RS
86		Kadambur	Safe	9.0078	77.9024	RS
87		Kadambur	Safe	9.0016	77.9075	RS
88		Kadambur	Safe	8.9960	77.9112	RS
89		Kadambur	Safe	9.0295	77.8504	RS
90		Kadambur	Safe	9.0171	77.8093	RS
91		Kadambur	Safe	8.9996	77.8343	RS
92		Kadambur	Safe	9.0016	77.8277	RS
93		Kadambur	Safe	9.0142	77.8506	RS
94		Kamanaickanpatti	Safe	9.0886	77.8706	CD
95		Kamanaickanpatti	Safe	9.0833	77.9060	CD
96		Kamanaickanpatti	Safe	9.0481	77.9084	CD
97		Kamanaickanpatti	Safe	9.0171	77.9231	CD
98		Kamanaickanpatti	Safe	9.0848	77.8915	CD
99		Kamanaickanpatti	Safe	9.0805	77.8750	CD
100		Kamanaickanpatti	Safe	9.0691	77.9006	CD
101		Kamanaickanpatti	Safe	9.0939	77.8704	NB
102		Kamanaickanpatti	Safe	9.0568	77.8905	NB
103		Kamanaickanpatti	Safe	9.1221	77.8890	NB
104		Kamanaickanpatti	Safe	9.0861	77.9286	NB
105		Kamanaickanpatti	Safe	9.0788	77.9175	NB
106		Kamanaickanpatti	Safe	9.0528	77.9531	NB
107		Kamanaickanpatti	Safe	9.0448	77.9364	NB
108		Kamanaickanpatti	Safe	9.0871	77.9428	NB
109		Kamanaickanpatti	Safe	9.0553	77.9303	NB

110		Kamanaickanpatti	Safe	9.0998	77.8983	NB
111		Kamanaickanpatti	Safe	9.0946	77.9052	NB
112		Kamanaickanpatti	Safe	9.0865	77.9141	NB
113		Kamanaickanpatti	Safe	9.0968	77.8752	RRR
114		Kamanaickanpatti	Safe	9.0831	77.8770	RRR
115		Kamanaickanpatti	Safe	9.0856	77.9091	RRR
116		Kamanaickanpatti	Safe	9.0748	77.9094	RRR
117		Kamanaickanpatti	Safe	9.0730	77.9016	RRR
118		Kamanaickanpatti	Safe	9.0813	77.8974	RRR
119		Kamanaickanpatti	Safe	9.0735	77.9460	RRR
120		Kamanaickanpatti	Safe	9.0800	77.9401	RRR
121		Kamanaickanpatti	Safe	9.0460	77.9529	RRR
122		Kamanaickanpatti	Safe	9.0313	77.9609	RRR
123		Kamanaickanpatti	Safe	9.1131	77.8966	RS
124		Kamanaickanpatti	Safe	9.0946	77.9103	RS
125		Kamanaickanpatti	Safe	9.0804	77.9239	RS
126		Kamanaickanpatti	Safe	9.0583	77.9487	RS
127		Kamanaickanpatti	Safe	9.0476	77.9288	RS
128		Kamanaickanpatti	Safe	9.0721	77.8936	RS
129		Kamanaickanpatti	Safe	9.0540	77.8892	RS
130		Kamanaickanpatti	Safe	9.0993	77.9173	RS
131		Kamanaickanpatti	Safe	9.0120	77.9286	RS
132		Kamanaickanpatti	Safe	9.0063	77.9239	RS
133		Kamanaickanpatti	Safe	9.0017	77.9145	RS
134		Kamanaickanpatti	Safe	9.0596	77.9310	RS
135		Ottapidaram	Safe	8.9261	78.0089	CD
136		Ottapidaram	Safe	8.9200	78.0143	CD
137		Ottapidaram	Safe	8.8989	78.0102	CD
138		Ottapidaram	Safe	8.8884	77.9882	CD

139		Ottapidaram	Safe	8.8886	77.9769	CD
140		Ottapidaram	Safe	8.9284	78.0058	NB
141		Ottapidaram	Safe	8.9170	77.9647	NB
142		Ottapidaram	Safe	8.8981	77.9638	NB
143		Ottapidaram	Safe	8.8819	77.9859	NB
144		Ottapidaram	Safe	8.8581	78.0276	NB
145		Ottapidaram	Safe	8.8827	78.0707	NB
146		Ottapidaram	Safe	8.8760	78.0698	NB
147		Ottapidaram	Safe	8.8819	78.0590	NB
148		Ottapidaram	Safe	8.8787	78.0364	NB
149		Ottapidaram	Safe	8.8920	78.0557	NB
150		Ottapidaram	Safe	8.8958	78.0586	NB
151		Ottapidaram	Safe	8.8539	78.0854	NB
152		Ottapidaram	Safe	8.9200	78.0166	RRR
153		Ottapidaram	Safe	8.9015	78.0156	RRR
154		Ottapidaram	Safe	8.9320	78.0141	RRR
155		Ottapidaram	Safe	8.9274	78.0137	RRR
156		Ottapidaram	Safe	8.8869	77.9985	RRR
157		Ottapidaram	Safe	8.8882	77.9919	RRR
158		Ottapidaram	Safe	8.8789	77.9892	RRR
159		Ottapidaram	Safe	8.8792	77.9998	RRR
160		Ottapidaram	Safe	8.9004	77.9892	RRR
161		Ottapidaram	Safe	8.9042	77.9834	RRR
162		Ottapidaram	Safe	8.8652	78.0229	RRR
163		Ottapidaram	Safe	8.8756	78.0224	RRR
164		Ottapidaram	Safe	8.8676	78.0559	RRR
165		Ottapidaram	Safe	8.9040	78.0486	RS
166		Ottapidaram	Safe	8.9109	78.0395	RS
167		Ottapidaram	Safe	8.9341	78.0372	RS
168		Ottapidaram	Safe	8.8657	78.0187	RS

169		Ottapidaram	Safe	8.9198	77.9925	RS
170		Ottapidaram	Safe	8.8768	78.0840	RS
171		Ottapidaram	Safe	8.8646	78.0866	RS
172		Ottapidaram	Safe	8.8724	78.0536	RS
173		Ottapidaram	Safe	8.8762	78.0420	RS
174		Ottapidaram	Safe	8.8421	78.0715	RS
174		Ottapidaram	Safe	8.8440	78.0848	RS
175		Ottapidaram	Safe	8.8949	78.0530	RS
176		Ottapidaram	Safe	8.8520	78.0254	RS
177		Ottapidaram	Safe	8.8874	78.0310	RS
178		Ottapidaram	Safe	8.9101	77.9628	RS
179		Ottapidaram	Safe	8.9017	77.9699	RS
180		Ottapidaram	Safe	8.8697	78.0684	RS
181		Ottapidaram	Safe	8.8560	78.0715	RS
182		Ottapidaram	Safe	8.8551	78.0387	RS
183		Ottapidaram	Safe			

CD: Check Dam, NB: Nala Bund, RS: Recharge shaft, RRR: recharge shaft with revival

Annexure2 : Details of the Artificial recharge structures implemented by the State Groundwater Department

Sl No.	District	Village	Structure	Locatin	Depertment
1	Thoothukkudi	Kayathar	CD	Sevalapperi	PWD
2	Thoothukkudi	Kayathar	CD	Vellalankottai	PWD
3	Thoothukkudi	Kayathar	CD	Vanaramutti	PWD
4	Thoothukkudi	Kayathar	CD	Vellalankottai	PWD
5	Thoothukkudi	Kovilpatti	CD	Ilambuvanam	PWD
6	Thoothukkudi	Kovilpatti	CD	Ayyakottaiyur	PWD
7	Thoothukkudi	Ottapidaram	CD	Eppodumvendran	PWD
8	Thoothukkudi	Pudur	CD	Nambipuram	PWD
9	Thoothukkudi	Vilathikulam	CD	Arungulam	PWD
10	ThoothukKudi	Alwarthirunagari	CD	Karungadal	AED
11	ThoothukKudi	Alwarthirunagari	CD	Srivengateswara Puram	AED
12	ThoothukKudi	Alwarthirunagari	CD	Karungadal	AED
13	ThoothukKudi	Alwarthirunagari	CD	Kachchanavilai	AED
14	ThoothukKudi	Alwarthirunagari	CD	Kachchanavilai	AED
15	ThoothukKudi	Alwarthirunagari	CD	Karungadal	AED
16	ThoothukKudi	Alwarthirunagari	CD	Karungadal	AED
17	ThoothukKudi	Alwarthirunagari	CD	Karungadal	AED
18	ThoothukKudi	Alwarthirunagari	PP	Karungadal	AED
19	ThoothukKudi	Alwarthirunagari	CD	Kurukalperi	TWAD
20	ThoothukKudi	Alwarthirunagari	CD	Xavierpuram	TWAD
21	ThoothukKudi	Alwarthirunagari	CD	Senkulam	TWAD
22	ThoothukKudi	Alwarthirunagari	CD	Udaiyarkulam	TWAD
23	ThoothukKudi	Alwarthirunagari	CD	Melavellamadam	TWAD
24	ThoothukKudi	Alwarthirunagari	RBW	Karuvelampadu	TWAD
25	ThoothukKudi	Alwarthirunagari	RS	Karunkadal	AED
26	ThoothukKudi	Alwarthirunagari	RS	Karunkadal	AED

27	ThoothukKudi	Alwarthirunagari	RS	Aadhinathapuram	TWAD
28	ThoothukKudi	Alwarthirunagari	RS	Aadhinathapuram	TWAD
29	ThoothukKudi	Alwarthirunagari	RS	Alagiyamanavala Puram	TWAD
30	ThoothukKudi	Alwarthirunagari	RS	Alagiyamanavala Puram	TWAD
31	ThoothukKudi	Alwarthirunagari	RS	Angamangalam	TWAD
32	ThoothukKudi	Alwarthirunagari	RS	Cambellahbad	TWAD
33	ThoothukKudi	Alwarthirunagari	RS	Kadayanodai	TWAD
34	ThoothukKudi	Alwarthirunagari	RS	Kadayanodai	TWAD
35	ThoothukKudi	Alwarthirunagari	RS	Kurukattur	TWAD
36	ThoothukKudi	Alwarthirunagari	RS	Kurukattur	TWAD
37	ThoothukKudi	Karungulam	CD	Therkkukaraseri	TWAD
38	ThoothukKudi	Karungulam	CD	SingathaKurichi	TWAD
39	ThoothukKudi	Karungulam	CD	VadakkuKaraseri	TWAD
40	ThoothukKudi	Karungulam	CD	TherkkuKaraseri	AED
41	ThoothukKudi	Karungulam	CD	TherkkuKaraseri	AED
42	ThoothukKudi	Karungulam	CD	Ellainayakkan Patti	AED
43	ThoothukKudi	Karungulam	CD	Ellainayakkan Patti	AED
44	ThoothukKudi	Karungulam	CD	Ellainayakkan Patti	AED
45	ThoothukKudi	Karungulam	CD	Ellainayakkan Patti	AED
46	ThoothukKudi	Karungulam	CD	Ellainayakkan Patti	AED
47	ThoothukKudi	Karungulam	CD	Seithunganallur	AED
48	ThoothukKudi	Karungulam	CD	Seithunganallur	AED

49	ThoothukKudi	Karungulam	CD	Vadakkukaraseri	AED
50	ThoothukKudi	Karungulam	CD	Seithunganallur	AED
51	ThoothukKudi	Karungulam	RS	Poovani	AED
52	ThoothukKudi	Karungulam	Pond	TherkkuKaraseri	AED
53	ThoothukKudi	Kayathar	CD	Salai Naickanpatti	TWAD
54	ThoothukKudi	Kayathar	CD	Chettikurichi	TWAD
55	ThoothukKudi	Kayathar	CD	Velukandapuram	TWAD
56	ThoothukKudi	Kayathar	CD	Valasalpatti	TWAD
57	ThoothukKudi	Kayathar	CD	Veppankulam	TWAD
58	ThoothukKudi	Kayathar	CD	Achankulam	TWAD
59	ThoothukKudi	Kayathar	CD	Akilandapuram	TWAD
60	ThoothukKudi	Kayathar	CD	K.Sivagnapuram	TWAD
61	ThoothukKudi	Kayathar	CD	Kuppanapuram	TWAD
62	ThoothukKudi	Kayathar	CD	Kappulingampatti	TWAD
63	ThoothukKudi	Kayathar	CD	Therkumailadi	TWAD
64	ThoothukKudi	Kayathar	CD	TherkkuIlandaikulam	TWAD
65	ThoothukKudi	Kayathar	CD	Karadikulam Ceylon Colony	TWAD
66	ThoothukKudi	Kayathar	CD	Mudhukkalankulam	TWAD
67	ThoothukKudi	Kayathar	CD	SannathuPudukudi	TWAD
68	ThoothukKudi	Kayathar	CD	Thulukkarpatti	TWAD
69	ThoothukKudi	Kayathar	CD	Koolaidevanpatti	TWAD
70	ThoothukKudi	Kayathar	CD	Akilandapuram	TWAD
71	ThoothukKudi	Kayathar	CD	Chettikurcihi	TWAD
72	ThoothukKudi	Kayathar	CD	Vellalankottai	TWAD
73	ThoothukKudi	Kayathar	CD	Ayyanaroothu	TWAD
74	ThoothukKudi	Kayathar	CD	Podupatti	TWAD
75	ThoothukKudi	Kayathar	CD	Alagappapuram	TWAD
76	ThoothukKudi	Kayathar	FP	Pannikulam	AED

77	ThoothukKudi	Kayathar	FP	Pannikulam	AED
78	ThoothukKudi	Kayathar	CD	K. Kumarapuram	AED
79	ThoothukKudi	Kayathar	CD	K. Kumarapuram	AED
80	ThoothukKudi	Kayathar	CD	Kuppanapuram	AED
81	ThoothukKudi	Kayathar	CD	South Vandanam	AED
82	ThoothukKudi	Kayathar	CD	Akilandapuram	AED
83	ThoothukKudi	Kayathar	CD	Akilandapuram	AED
84	ThoothukKudi	Kayathar	CD	Kalampatti	AED
85	ThoothukKudi	Kayathar	CD	Kalampatti	AED
86	ThoothukKudi	Kayathar	CD	Kalampatti	AED
87	ThoothukKudi	Kayathar	CD	Guruvinatham	AED
88	ThoothukKudi	Kayathar	Pond	Kuppanapuram	AED
89	ThoothukKudi	Kayathar	Pond	Veilukandapuram	TWAD
90	ThoothukKudi	Kayathar	PP	Akilandapuram	AED
91	ThoothukKudi	Kayathar	PPS	South Vandanam	AED
92	ThoothukKudi	Kayathar	RS	Chettikurichi	TWAD
93	ThoothukKudi	Kayathar	RS	Sannathupudukudi	TWAD
94	ThoothukKudi	Kayathar	RS	Sannathupudukudi	TWAD
95	ThoothukKudi	Kayathar	RS	Rajapudukudi	TWAD
96	ThoothukKudi	Kayathar	RS	Rajapudukudi	TWAD
97	ThoothukKudi	Kayathar	RS	Ahilandapuram	TWAD
98	ThoothukKudi	Kayathar	RS	Karadikulam	TWAD
99	ThoothukKudi	Kayathar	RS	Kalankaraipatti	TWAD
100	ThoothukKudi	Kayathar	RS	Kalankaraipatti	TWAD
101	ThoothukKudi	Kayathar	RS	Kuruvinatham	TWAD
102	ThoothukKudi	Kayathar	CD	Savalaperi	TWAD
103	ThoothukKudi	Kayathar	CD	Lakshmipuram	TWAD
104	ThoothukKudi	Kayathar	CD	Kumaragiri	TWAD
105	ThoothukKudi	Kayathar	CD	Kumaragiri	TWAD
106	ThoothukKudi	Kayathar	CD	Ilanthaipatti	TWAD
107	ThoothukKudi	Kayathar	CD	Koppampatty	TWAD

108	ThoothukKudi	Kayathar	CD	Parasuramapuram	TWAD
109	ThoothukKudi	Kayathar	CD	Veppankulam	TWAD
110	ThoothukKudi	Kayathar	CD	Subramaniapuram	TWAD
111	ThoothukKudi	Kayathar	CD	Thalayalnadanthankulam	TWAD
112	ThoothukKudi	Kovilpatti	CD	Ilampuvanam	TWAD
113	ThoothukKudi	Kovilpatti	CD	Ayyakottaiyoor	TWAD
114	ThoothukKudi	Kovilpatti	CD	Karisalkulam	TWAD
115	ThoothukKudi	Kovilpatti	CD	Chidambarapuram	TWAD
116	ThoothukKudi	Kovilpatti	CD	Illumbuvanam	TWAD
117	ThoothukKudi	Kovilpatti	CD	Uthupatti	TWAD
118	ThoothukKudi	Kovilpatti	CD	Indira Nagar Katchalapuram	TWAD
119	ThoothukKudi	Kovilpatti	CD	Meenachipuram	TWAD
120	ThoothukKudi	Kovilpatti	CD	Chinnamalaikundru	TWAD
121	ThoothukKudi	Kovilpatti	CD	Duraiyur	TWAD
122	ThoothukKudi	Kovilpatti	CD	Inanmmaniyachi	TWAD
123	ThoothukKudi	Kovilpatti	CD	Manjanaickenpatti	TWAD
124	ThoothukKudi	Kovilpatti	CD	Annaitheresanagar (New)	TWAD
125	ThoothukKudi	Kovilpatti	CD	Viswanathanagar	TWAD
126	ThoothukKudi	Kovilpatti	CD	Lakshmi Mill Mela Colony	TWAD
127	ThoothukKudi	Kovilpatti	FP	Aavalnatham	AED
128	ThoothukKudi	Kovilpatti	FP	Avalnattam	AED
129	ThoothukKudi	Kovilpatti	FP	Avalnattam	AED
130	ThoothukKudi	Kovilpatti	FP	Villiseri -1	AED
131	ThoothukKudi	Kovilpatti	CD	Keela Eral	AED
132	ThoothukKudi	Kovilpatti	CD	Keela Eral	AED
133	ThoothukKudi	Kovilpatti	CD	Nakkalakkottai	AED
134	ThoothukKudi	Kovilpatti	CD	Nakkalakkottai	AED
135	ThoothukKudi	Kovilpatti	CD	Nakkalakkottai	AED
136	ThoothukKudi	Kovilpatti	CD	Nakkalakkottai	AED

137	ThoothukKudi	Kovilpatti	CD	Sivanthipatti	AED
138	ThoothukKudi	Kovilpatti	CD	Sivanthipatti	AED
139	ThoothukKudi	Kovilpatti	CD	Uthupatti	AED
140	ThoothukKudi	Kovilpatti	CD	Uthupatti	AED
141	ThoothukKudi	Kovilpatti	CD	Kilavipatti	AED
142	ThoothukKudi	Kovilpatti	CD	Uthupatti	AED
143	ThoothukKudi	Kovilpatti	CD	Uthupatti	AED
144	ThoothukKudi	Kovilpatti	CD	Valampatti	AED
145	ThoothukKudi	Kovilpatti	CD	Valampatti	AED
146	ThoothukKudi	Kovilpatti	CD	Sivanthipatti	AED
147	ThoothukKudi	Kovilpatti	CD	Nakkalakkottai	AED
148	ThoothukKudi	Kovilpatti	PP	Navalakkampatti	AED
149	ThoothukKudi	Kovilpatti	PPS	Sivanthipatti	AED
150	ThoothukKudi	Kovilpatti	RS	Mudukkummendanpatti	TWAD
151	ThoothukKudi	Kovilpatti	RS	Mudukkummendanpatti	TWAD
152	ThoothukKudi	Kovilpatti	RS	Thonugal	TWAD
153	ThoothukKudi	Kovilpatti	RS	Thonugal	TWAD
154	ThoothukKudi	Kovilpatti	RS	Thonugal	TWAD
155	ThoothukKudi	Kovilpatti	RS	Idaiseval	TWAD
156	ThoothukKudi	Kovilpatti	RS	Idaiseval	TWAD
157	ThoothukKudi	Kovilpatti	RS	Uthupatti	TWAD
158	ThoothukKudi	Kovilpatti	RS	Uthupatti	TWAD
159	ThoothukKudi	Kovilpatti	RS	Manthithoppu	TWAD
160	ThoothukKudi	Ottapidaram	CD	Athanur	TWAD
161	ThoothukKudi	Ottapidaram	CD	Panchalankurichi	TWAD
162	ThoothukKudi	Ottapidaram	CD	Governagiri	TWAD
163	ThoothukKudi	Ottapidaram	CD	Ottanatham	TWAD
164	ThoothukKudi	Ottapidaram	CD	Jagaveerapandiapuram	TWAD
165	ThoothukKudi	Ottapidaram	CD	Kalappaipatti	TWAD
166	ThoothukKudi	Ottapidaram	CD	Mullur	TWAD

167	ThoothukKudi	Ottapidaram	CD	Sillankulam	TWAD
168	ThoothukKudi	Ottapidaram	CD	Vala Samudram	TWAD
169	ThoothukKudi	Ottapidaram	CD	K.Kailasapuram	TWAD
170	ThoothukKudi	Ottapidaram	CD	Nagampatti	TWAD
171	ThoothukKudi	Ottapidaram	CD	Onamakulam	TWAD
172	ThoothukKudi	Ottapidaram	CD	Kombadi	TWAD
173	ThoothukKudi	Ottapidaram	CD	Goplalapuram	TWAD
174	ThoothukKudi	Ottapidaram	CD	Athanur	TWAD
175	ThoothukKudi	Ottapidaram	CD	S.Pudur	TWAD
176	ThoothukKudi	Ottapidaram	CD	Keelamangalam Colony	TWAD
177	ThoothukKudi	Ottapidaram	CD	Panchalankurichi	TWAD
178	ThoothukKudi	Ottapidaram	CD	Paraikuttam	TWAD
179	ThoothukKudi	Ottapidaram	CD	Melamangalam	TWAD
180	ThoothukKudi	Ottapidaram	CD	Eppudumvendran	TWAD
181	ThoothukKudi	Ottapidaram	CD	Pasuvanthanai	TWAD
182	ThoothukKudi	Ottapidaram	CD	Thalaiyuthu	TWAD
183	ThoothukKudi	Ottapidaram	CD	Malaipatti	TWAD
184	ThoothukKudi	Ottapidaram	RBW	Paramanpacheri	TWAD
185	ThoothukKudi	Ottapidaram	FP	Chandragiri	AED
186	ThoothukKudi	Ottapidaram	FP	Panjalankurichchi	AED
187	ThoothukKudi	Ottapidaram	CD	Paraikuttam	AED
188	ThoothukKudi	Ottapidaram	CD	Paraikuttam	AED
189	ThoothukKudi	Ottapidaram	CD	Paraikuttam	AED
190	ThoothukKudi	Ottapidaram	CD	Panjalamkurichi	AED
191	ThoothukKudi	Ottapidaram	CD	V.Meenakshi Puram	AED

192	ThoothukKudi	Ottapidaram	CD	V.Meenakshi Puram	AED
193	ThoothukKudi	Ottapidaram	CD	Panjalamkurichi	AED
194	ThoothukKudi	Ottapidaram	CD	Panjalamkurichi	AED
195	ThoothukKudi	Ottapidaram	CD	V.Meenakshi Puram	AED
196	ThoothukKudi	Ottapidaram	CD	V.Meenakshi Puram	AED
197	ThoothukKudi	Ottapidaram	Pond	K.Venkatachalapuram	TWAD
198	ThoothukKudi	Ottapidaram	Pond	Muthu Kumarapuram	TWAD
199	ThoothukKudi	Ottapidaram	PP	Venkateswara Puram	AED
200	ThoothukKudi	Ottapidaram	PPS	Parivallikottai	AED
201	ThoothukKudi	Ottapidaram	PP	Sankarajapuram	TWAD
202	ThoothukKudi	Ottapidaram	PP	Ottanatham	TWAD
203	ThoothukKudi	Ottapidaram	PP	Ottapidaram	TWAD
204	ThoothukKudi	Ottapidaram	PP	VadakkuKailasapuram	TWAD
205	ThoothukKudi	Ottapidaram	PP	S.Kailasapuram	TWAD
206	ThoothukKudi	Ottapidaram	PP	Veppalodai	TWAD
207	ThoothukKudi	Pudur	CD	Keela Arunachalapuram	TWAD
208	ThoothukKudi	Pudur	CD	L.V.Puram	TWAD
209	ThoothukKudi	Pudur	CD	Nadukattur	TWAD
210	ThoothukKudi	Pudur	CD	Bhavanipuram	TWAD
211	ThoothukKudi	Pudur	CD	Vannipatti	TWAD
212	ThoothukKudi	Pudur	CD	Melanambipuram	TWAD
213	ThoothukKudi	Pudur	RBW	Keelakaranthai ADC	TWAD
214	ThoothukKudi	Pudur	FP	Kanthasamypuram	AED
215	ThoothukKudi	Pudur	CD	Karuppur	AED

216	ThoothukKudi	Pudur	CD	Muthalapuram	AED
217	ThoothukKudi	Pudur	CD	Muthalapuram	AED
218	ThoothukKudi	Pudur	CD	Muthalapuram	AED
219	ThoothukKudi	Pudur	CD	Muthalapuram	AED
220	ThoothukKudi	Pudur	CD	Muthalapuram	AED
221	ThoothukKudi	Pudur	CD	Muthalapuram	AED
222	ThoothukKudi	Pudur	CD	Karuppur	AED
223	ThoothukKudi	Pudur	CD	Karuppur	AED
224	ThoothukKudi	Pudur	CD	Muthulapuram	AED
225	ThoothukKudi	Pudur	CD	Senkottai	AED
226	ThoothukKudi	Pudur	CD	Muthalapuram	AED
227	ThoothukKudi	Pudur	Pond	Iyyankarisalkulam	AED
228	ThoothukKudi	Pudur	Pond	K.Duraisamypuram	TWAD
229	ThoothukKudi	Pudur	Pond	Lakshmipuram	TWAD
230	ThoothukKudi	Pudur	Pond	Mittavadamalapuram	TWAD
231	ThoothukKudi	Pudur	Pond	Ramachandrapuram	TWAD
232	ThoothukKudi	Pudur	PPS	Iyyankarisalkulam	AED
233	ThoothukKudi	Pudur	PP	Karuppusamikoilpatti	TWAD
234	ThoothukKudi	Pudur	PP	Kottur	TWAD
235	ThoothukKudi	Pudur	RS	Mettilpatti	TWAD
236	ThoothukKudi	Pudur	RS	Mettilpatti	TWAD
237	ThoothukKudi	Pudur	RS	Muthusamypuram	TWAD
238	ThoothukKudi	Pudur	RS	Muthusamypuram	TWAD
239	ThoothukKudi	Pudur	RS	Melanambipuram	TWAD
240	ThoothukKudi	Pudur	RS	Melanambipuram	TWAD
241	ThoothukKudi	Pudur	RS	Sinnamanaickenpatti	TWAD
242	ThoothukKudi	Pudur	RS	Sinnamanaickenpatti	TWAD
243	ThoothukKudi	Pudur	RS	Sivalarpatti	TWAD
244	ThoothukKudi	Pudur	RS	Veerappapatti	TWAD
245	ThoothukKudi	Sattankulam	CD	Komaneri	TWAD
246	ThoothukKudi	Sattankulam	CD	Nedungulam	TWAD

247	ThoothukKudi	Sattankulam	CD	Vagaineri	TWAD
248	ThoothukKudi	Sattankulam	CD	Padukkapattu	TWAD
249	ThoothukKudi	Sattankulam	CD	Samathuvapuram	TWAD
250	ThoothukKudi	Sattankulam	CD	Pannamparai South	TWAD
251	ThoothukKudi	Sattankulam	CD	Komaneri	TWAD
252	ThoothukKudi	Sattankulam	CD	Subbarayapuram	TWAD
253	ThoothukKudi	Sattankulam	FP	Pudhukulam	AED
254	ThoothukKudi	Sattankulam	CD	Kombankulam	AED
255	ThoothukKudi	Sattankulam	CD	Nedungulam	AED
256	ThoothukKudi	Sattankulam	CD	Nedungulam	AED
257	ThoothukKudi	Sattankulam	CD	Pannamparai	AED
258	ThoothukKudi	Sattankulam	CD	Pannamparai	AED
259	ThoothukKudi	Sattankulam	CD	Sathankulam	AED
260	ThoothukKudi	Sattankulam	CD	Sathankulam	AED
261	ThoothukKudi	Sattankulam	PP	Komaneri	AED
262	ThoothukKudi	Sattankulam	CD	Nedungulam	AED
263	ThoothukKudi	Sattankulam	CD	Vagaineri	TWAD
264	ThoothukKudi	Sattankulam	FP	Nedungulam	AED
265	ThoothukKudi	Sattankulam	CD	Kommadikottai	AED
266	ThoothukKudi	Sattankulam	CD	Kommadikottai	AED
267	ThoothukKudi	Sattankulam	CD	Kommadikottai	AED
268	ThoothukKudi	Sattankulam	CD	Muthalur	AED
269	ThoothukKudi	Sattankulam	CD	Nedungulam	AED
270	ThoothukKudi	Sattankulam	CD	Nedungulam	AED
271	ThoothukKudi	Sattankulam	CD	Padukkapattu	AED
272	ThoothukKudi	Sattankulam	CD	Padukkapattu	AED
273	ThoothukKudi	Sattankulam	CD	Padukkapattu	AED
274	ThoothukKudi	Sattankulam	PP	Komaneri	AED
275	ThoothukKudi	Sattankulam	RS	Nedungulam	AED
276	ThoothukKudi	Sattankulam	RS	Nedungulam	AED
277	ThoothukKudi	Srivaikundam	CD	Pudupatti	TWAD

278	ThoothukKudi	Srivaikundam	CD	Adaikalapuram	TWAD
279	ThoothukKudi	Srivaikundam	CD	Aniyaparanallur	TWAD
280	ThoothukKudi	Srivaikundam	CD	Thannuthu	AED
281	ThoothukKudi	Srivaikundam	CD	Thannuthu	AED
282	ThoothukKudi	Srivaikundam	CD	Thannuthu	AED
283	ThoothukKudi	Srivaikundam	CD	Thannuthu	AED
284	ThoothukKudi	Srivaikundam	CD	Thannuthu	AED
285	ThoothukKudi	Srivaikundam	CD	Aniyabaranallur	AED
286	ThoothukKudi	Srivaikundam	CD	Aniyabaranallur	AED
287	ThoothukKudi	Srivaikundam	RS	Aniyabaranallur, Srimoolakkarai	AED
288	ThoothukKudi	Thoothukudi	CD	Sevalur	TWAD
289	ThoothukKudi	Thoothukudi	CD	Thimmarajapuram	TWAD
290	ThoothukKudi	Thoothukudi	RBW	Athimarapatti	TWAD
291	ThoothukKudi	Thoothukudi	CD	Mudivaithanendal	AED
292	ThoothukKudi	Thoothukudi	CD	Mudivaithanendal	AED
293	ThoothukKudi	Thoothukudi	CD	Mudivaithanendal	AED
294	ThoothukKudi	Thoothukudi	CD	Mudivaithanendal	AED
295	ThoothukKudi	Thoothukudi	CD	Mudivaithanendal	AED
296	ThoothukKudi	Thoothukudi	CD	Thimmarajapuram	AED
297	ThoothukKudi	Thoothukudi	CD	Ramasamypuram	AED
298	ThoothukKudi	Thoothukudi	CD	Ramasamypuram	AED
299	ThoothukKudi	Thoothukudi	RS	Peroorani, Allikulam	AED
300	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED

301	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
302	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
303	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
304	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
305	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
306	ThoothukKudi	Udangudi	CD	Lakshmipuram	AED
307	ThoothukKudi	Vilathikulam	CD	Vilathikulam	TWAD
308	ThoothukKudi	Vilathikulam	CD	Kazhugosalapuram	TWAD
309	ThoothukKudi	Vilathikulam	RBW	Ramanaoothu	TWAD
310	ThoothukKudi	Vilathikulam	FP	Arunkulam	AED
311	ThoothukKudi	Vilathikulam	FP	Guruvarpatti	AED
312	ThoothukKudi	Vilathikulam	FP	Keelavilathikulam	AED
313	ThoothukKudi	Vilathikulam	FP	Marthandampatti	AED
314	ThoothukKudi	Vilathikulam	FP	T.Thangammalpuram	AED
315	ThoothukKudi	Vilathikulam	FP	Vathalakkarai	AED
316	ThoothukKudi	Vilathikulam	FP	Vilathikulam	AED
317	ThoothukKudi	Vilathikulam	FP	Keela Vilathikulam	AED
318	ThoothukKudi	Vilathikulam	CD	Arunkulam	AED
319	ThoothukKudi	Vilathikulam	CD	Kumarasakkanapuram	AED
320	ThoothukKudi	Vilathikulam	CD	Kumarasakkanapuram	AED
321	ThoothukKudi	Vilathikulam	CD	Marthandampatti	AED
322	ThoothukKudi	Vilathikulam	CD	Kalugachalapuram	AED
323	ThoothukKudi	Vilathikulam	CD	Marthandampatti	AED
324	ThoothukKudi	Vilathikulam	CD	Marthandampatti	AED
325	ThoothukKudi	Vilathikulam	PP	Thalaikattupuram	AED
326	ThoothukKudi	Vilathikulam	PPS	Arunkulam	AED

327	ThoothukKudi	Vilathikulam	PP	Namasivayapuram	TWAD
328	ThoothukKudi	Vilathikulam	PP	Ramachandrapuram	TWAD
329	ThoothukKudi	Vilathikulam	RS	Soorangudi	TWAD
330	ThoothukKudi	Vilathikulam	RS	K.Thangammal Puram	TWAD
331	ThoothukKudi	Vilathikulam	RS	Melashanmuga Puram	TWAD
332	ThoothukKudi	Vilathikulam	RS	Melashanmuga Puram	TWAD
333	ThoothukKudi	Vilathikulam	RS	Melashanmuga Puram	TWAD
334	ThoothukKudi	Vilathikulam	RS	Melamanthai	TWAD
335	ThoothukKudi	Vilathikulam	RS	Thathaneri	TWAD
336	ThoothukKudi	Vilathikulam	RS	Arunkulam	TWAD
337	ThoothukKudi	Vilathikulam	RS	Arunkulam	TWAD
338	ThoothukKudi	Vilathikulam	RS	Sivagnanapuram	TWAD

Annexure III: Groundwater Resources of KallarAquifer System

Assessment Unit (Firka)	Annual extractable Groundwater Recharge Ham	Existing Groundwater Extraction for Irrigation in Ha m	Existing Grroundwater extraction for industrial Water supply in Ha m	Existing Grroundwater extraction for Domestic Water supply in Ha m	Existing Grroundwater extraction for All uses in Ha m	Allocation for domestic and industrial water supply in Ha m	Net Groundwater Availability for future irrigation extraction in Ha m	Stage of Groundwater extraction in %
Kalugumalai	1219.46	422.00	0.00	40.67	462.66	43.14	754.33	37.94
Nallathinputhur	892.05	422.00	0.00	30.81	452.81	32.69	437.36	50.76
Ettayapuram	784.83	321.00	0.00	22.48	343.48	23.85	439.98	43..76
Kammanaickanpatti	865.08	452.00	0.00	24.27	476.27	25.74	387.34	55.06
Kadambur	1088.91	648.00	8.00	18.93	674.93	20.09	412.82	61.98
Parivalikotatti	816.10	756.00	0.00	23.80	779.79	25.25	34.86	95.55

Cholapuram	695.80	302.00	0.00	10.44	312.44	11.08	382.72	44.90
Sivagnanapuram	621.90	36.60	0.00	18.01	54.61	19.11	566.19	8.78
Pasuvanthanai	826.21	366.80	4.00	31.37	402.17	33.28	42213	48.68
Eppodumvendram	916.70	98.00	0.00	27.79	125.79	29.48	789.22	13.72
Maniyachi	565.77	125.00	4.00	17.99	146.99	19.09	417.68	25.98
Ottapidaram	718.26	425.00	0.00	45.14	470.15	47.89	245.36	65.46
Vedanatham	1017.25	24.00	37.60	30.59	92.20	32.46	923.18	9.06
Vallanad	1198.95	472	0.00	40.14	512.14	42.59	684.36	42.72
Keelathataparai	667.83	87.80	0.00	22.10	109.90	23.45	556.58	16.46
Thoothukudi	280.15	9.00	22.60	82.52	114.12	87.55	161.00	40.74
Deivasayalpuram	1147.34	140.40	0.00	35.17	175.57	37.31	969.63	15.30
Mudivaithanandal	858.10	287.00	0.00	34.20	321.20	36.28	534.82	37.43
Pudukottai	1033.60	105.20	26.00	32.51	163.71	34.50	867.90	15.84
Basin total in Ham	16214.29	5499.8	102.2	588.93	6190.93	624.83	51778.33	38.18
Basin total in MCM	162.1429	54.998	1.022	5.8893	61.9093	6.2483	517.7833	

Annexure V: Exploratory well details in Kallar Basin

District	Block	Location	Long in DD	Latitude in DD	Depth Drilled (mbgl)	Casing depth for Hardrock(mbgl)	Major Lithology encountered	Most promising water bearing Zones (limit to max 3)					
							Nomenclature of Aquifer Atlas only to be used (only codes)	Zone 1		Zone 2		Zone 3	
								From	To	From	To	From	To
Thoothukudi	Ottapidaram	Eppodumvenran (GHSS)	78.0469	9.0202	200.00	17.50	GN03	72	72.5				
	Kayathar	EPPOTHUM VENDRAN (Govt. Hr. Secr School)	78.0469	9.02022	200.00	18.00	GN03	72	72.5				
Thoothukudi	Kayathar	KADAMBUR EW	77.8576	8.99407	200.00	18.00	GN03						
Thoothukudi	Kayathar	KADAMBUR OW (Water tank premises)	77.8476	8.99407	200.00	12.00	GN03						
Thoothukudi	Kathyar	KALANKARIYANPATTI EW (Primary Govt School) Kayatharu block,	77.7392	9.1358	121.90	21.00	GN03	34.0	35.0				
Thoothukudi	Kayathar	KAMANAYAKKANPATTI (Govt. Hr. Secr School, Kayatharu Block)	77.93606	9.07663	200.00	6.00	GN03						

Thoothukudi	Kayathar	KARISALKULAM EW (Govt Adidravidar welfare High School) Kayathar block,	77.7877	9.0063	200.00	6.00	GN03	136	136.5				
Thoothukudi	Ottapldaram	KURUKKUSALAI (G. H. S. School, Ottapidaram Block)	78.086	8.9319	200.00	6.00	GN03	32.36	33.6				
Thoothukudi	Kovilpatti	MELAERAL (e-seva centre)	78.00718	9.10663	200.00	12.00	GN03	138.04	139.04				
Thoothukudi	Ottapidaram	OTTANATHAM EW (Govt. Primary Health Centre)	78.0195	8.9068	200.00	14.00	CK01	38.98	39.9				
Thoothukudi	Thievaseyalpuram	SEKKARAKUDI (Govt. High School Ottapidaram Block)	77.9522	8.79192	200.00	6.00	GN03	55	61				
Thoothukudi	Ottapldaram	SILLANGULAM (Adhidravidar Boys Hostel, Kayatharu Block)	77.94281	8.9683	200.00	7.00	GN03						
Thoothukudi	Vilathikulam	SIVAGNANAPURAM (G. HS. S) OW	78.08671	9.05447	200.00	6.00	GN03	26.74	27.74				
Thoothukudi	Vilathikulam	SIVAGNANAPURAM EW	78.08661	9.05467	107.56	5.50	GN03	41.98	42.98				
Thoothukudi	Ottapidaram	Kailaspuram (Kilakottai) OW	77.8254	8.8598	200	8.88	GN03						
Thoothukudi	Pudukottai	M.Pudur (A.Thiyakurichi) EW	78.0038	8.7090	198	17.5	GN03						
Thoothukudi	Sattankulam	Meignanapuram EW	78.0022	8.4658	112	37.5	GN03	17	20				

Thoothukudi	Ottapidaram	Parivilikottai (Malaipatti) EW	77.8711	8.9180	200	9.06	GN03							
Thoothukudi	Pudukottai	Pudukottai (Panchalamkurichi A/C) EW	78.0458	8.7411	200	17.5	GN03	90	93					
Thoothukudi	Pudukottai	Thimmarajapuram EW	77.9919	8.7583	200	17.3	GN03	83	86					