



केन्द्रीय भूमिजल बोर्ड

जल शक्ति मंत्रालय, जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
भारत सरकार

Central Ground Water Board

Ministry of Jal Shakti,
Department of Water Resources, River Development
and Ganga Rejuvenation
Government of India

Report on

AQUIFER MAPPING AND MANAGEMENT PLAN

**Anekal Taluk, Bangalore Urban District,
Karnataka**

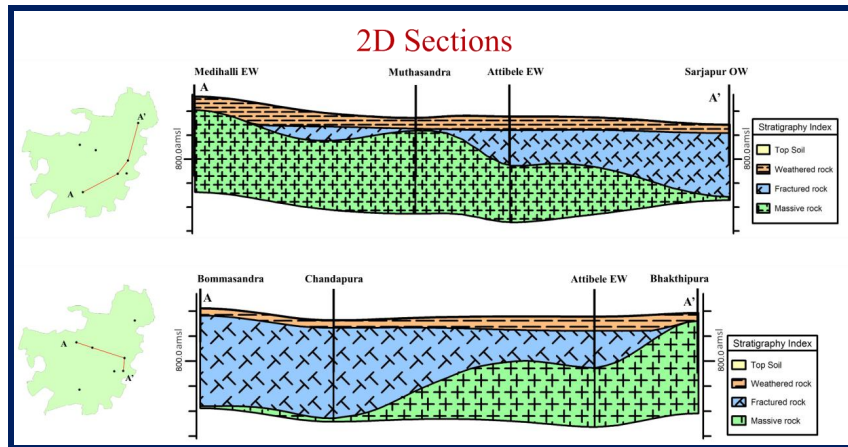
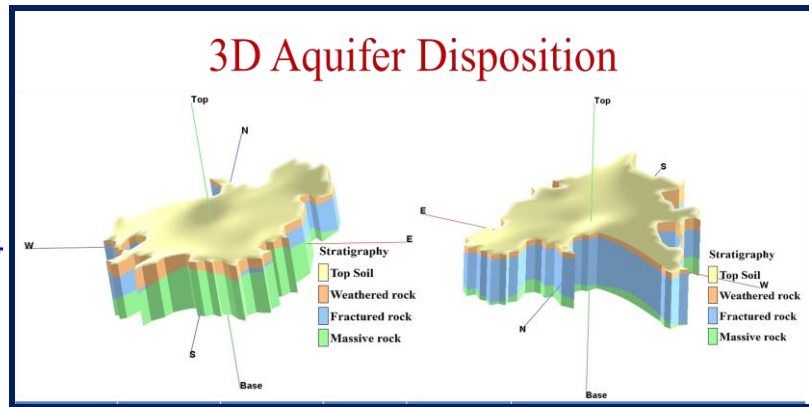
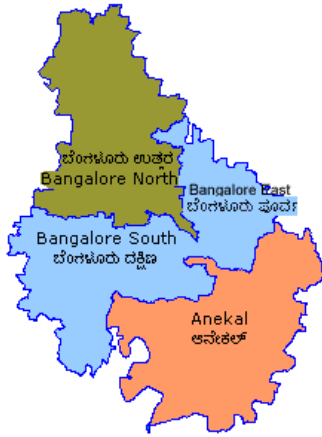
दक्षिण पश्चिमी क्षेत्र, बेंगलुरु
South Western Region, Bengaluru

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AQUIFER MAPS AND MANAGEMENT PLAN, ANEKAL TALUK, BANGALORE URBAN DISTRICT, KARNATAKA STATE (AAP: 2020-2021)



By

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AQUIFER MAPS AND MANAGEMENT PLAN, ANEKAL TALUK, BANGALORE URBAN DISTRICT, KARNATAKA STATE

1 SALIENT INFORMATION

Name of the Taluk:	ANEKAL
District:	Bangalore Urban
State:	Karnataka
Area:	548 sq. km.
Population:	517575 (2011 Census)
Annual Normal Rainfall:	853 mm

1.1 Aquifer Management Study Area

Anekal Taluk is located in South western part of Bangalore Urban district, Karnataka state covering an area of 548 Sq. Km. Anekal is located between 12° 44' 45.24"- 12° 41' 45.6" N latitude and 77° 42' 20.61"-77° 40' 14.33" E longitude with an average elevation of 915 m (3,001 ft) above the MSL.

Anekal is surrounded by Hoskote Taluk of Bangalore Rural district in the north, Tamilnadu state along South and South East, Bangalore South Taluk of Bangalore Urban district along west. Location map of the Taluk is shown in **Figure-1**.

Anekal taluk lies in the southern part of the Bangalore metropolitan area around 40 km from downtown Bangalore. It is a part of Bangalore revenue division with Anekal as taluk head quarter. There are 8 towns, 9 Hoblis, 28 Grama Panchayaths and 227 villages in the study area. The Taluk is well connected with good network of roads with National Highway 4 and the Bangalore-Chennai railway line connecting Hosakote to Bangalore and Chennai with other district roads forming good network of transport facility.

The electronics city, nerve centre of Bangalore's information technology, Jigani industrial estate, Bannerghatta wildlife sanctuary, KSIC silk industry firms are situated in Anekal Taluk.

Anekal Taluk covers part of Cauvery River and Krishna River basin and has no major rivers running through the region, Dry South Pennar river of Ponnaiyar basin is the only river in Anekal Taluk. Anekal has a handful of freshwater lakes and water tanks. Sewage laden Vrishabhavathi, tributary of Arkavathi flows through Anekal.

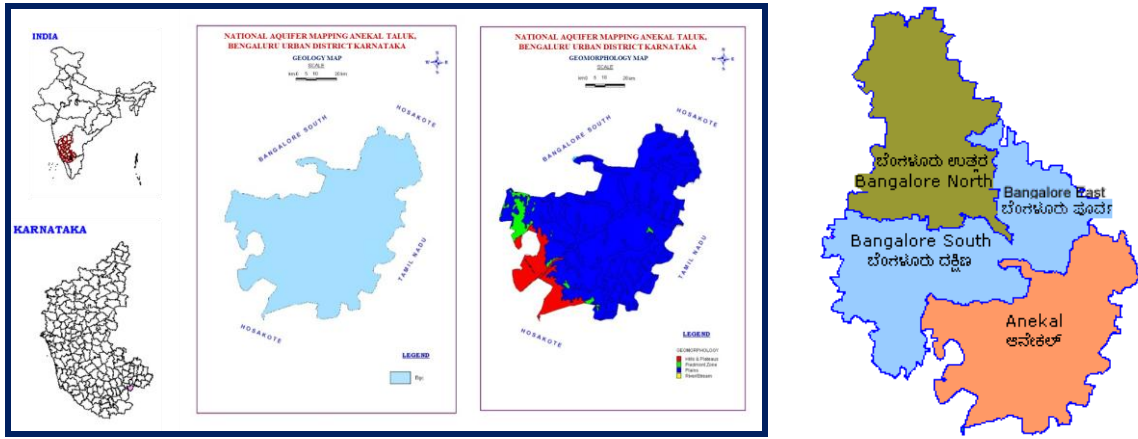


Figure-1: Location Map of Anekal Taluk.

1.2 Population

As per 2011 census, the total population in Anekal Taluk is 517575 out of which 282006 are males and 235569 are females, whereas 68.1% constitutes the rural population, 31.9 % in urban areas, which is the highest stake of Urban population in Bangalore Urban District. There are 130661 households in Anekal. The Taluk has an overall population density of 945 persons per sq.km. The decadal change is 14.90% in rural and 56.87% in urban population.

1.3 Rainfall

Semi-arid to humid climate prevails in Anekal with dryness and hot weather during major part of the year. The area falls under eastern Dry Agro-Climatic zone of Karnataka state and is categorized as drought prone. The climate of the Taluk is quite agreeable and free from extremes. The temperature in summer is in between 26.2°C to 34.2°C and in winter it is 15.1° to 21.8° C with normal temperature ranging from 21.1°C to 28°C. Maximum of 33°C in April to lowest mean maximum of 14°C in January. The mean monthly relative humidity is the lowest during the month of March at 44% and records highest between the months of June and October at 80 to 85%

The rainy season or South-West monsoon is from June to September followed by North-East monsoon and post-monsoon from October to December. Eastern Dry Agro-Climatic zone's characteristic of low rainfall pattern with more uniform and bi-modal distribution with average of 55 rainy days is observed in Anekal.

The mean monthly rainfall at Anekal Taluk is ranging from 1 mm during January to 181 mm during October. The Annual Normal rainfall (1981 to 2010) in the Taluk is 858 mm and the statistical analysis of rain fall data is presented in the **Table 1**.

Table 1: Statistical Analysis of Rainfall Data (1981 to 2010) of Anekal Taluk, Bangalore Urban District.

Item	JAN	FEB	MAR	APR	MAY	PRE	JUN	JUL	AUG	SEP	SW	OCT	NOV	DEC	NE	Annual
NRM	1	4	15	40	81	141	66	78	104	180	429	181	51	12	243	813
ST.DEV	3	14	31	43	59	88	57	58	66	104	156	118	51	18	141	256
CV%	349	332	209	108	73	63	86	74	63	58	36	65	100	149	58	31

1.4 Assessment of Drought

Rainfall data has been analyzed to assess the drought condition using for 102 years IMD Rain fall data and the results thus obtained are listed in the **Table-2**. It is observed that the Anekal Taluk has experienced no drought during 54 years, mild drought during 24 years, moderate drought during 21 years and severe drought during 3 years in 1920, 1923 and 2006 during the period. The probability of drought occurrence is once in 4 years.

Table 2: Classification of drought and its periodicity (IMD, 1971)

% of Deviation (Di)		>0	0 to -25	- 25 to 50	- 50 to - 75	< - 75	Probability of drought occurrences
Category		No drought	Mild (Normal)	Moderate	Severe	Acute	
		Years					
Taluk	Anekal	54	24	21	3	0	Once in 4 years

1.5 Agriculture & Irrigation

Anekal Taluk is having (68.1 %) of rural population wholly dependent on the rainfall for their agricultural activities. The land use pattern of the Taluk is presented in the **Table-3**.

Table 3: Land use pattern of Anekal Taluk (Area in Ha)

Geographical area	Area under forest	Area not available for cultivation	Uncultivable land	Area sown		
				Net sown area	Area sown more than once	Total sown/cropped area
53518	2215	26116	6654	15606	895	15711

1.5.1 Principle crops:

The only principle crop of the Taluk is Ragi which is grown in 9742 ha (39.33% to the total cropped area) which is normally rain fed crop. Followed by Fruits (2429 ha) and Vegetables (2146 ha), which are grown in both Kharif and Rabi seasons. The principle crops and the area grown are shown in **Table 4**.

Table 4: Principle crops grown in Anekal Taluk (Area in Ha).

Crops	Cereals			Pulses				Fruits	Flowers	Sericulture	Vegetables	Banana	Coconuts	Oil seeds		
	Ragi	Paddy	Maize	Avare	Tur	Horse gram	Others							Mustard seed	Niger seed	Ground nut
	9742	83	494	347	174	126	70	2429	645	419 ha	2146	100	314	-	45	46
Total	10319			732				2429	645	90 Villages	2146	100	314	90		

Source: District at a Glance 2016-2017, Govt. of Karnataka

1.5.2 Irrigation Practices:

In Anekal Taluk, the ground water is being developed from ground water structures like 4129 tube wells (District at a Glance 2016-2017) for irrigation purposes. The ground water thus developed from these structures were managed through water distribution irrigation practices by adopting- Open channel, Underground pipe, surface pipe, drip irrigation, sprinklers and others. Surface water is also available for irrigation through 1 lift irrigation scheme.

1.5.3 Ground water and surface water Irrigation:

In Anekal Taluk, ground water tapped through bore wells is the main source of irrigation. The details of surface water and ground water irrigation are in the **Table 5**.

Table 5: Details of irrigation in Anekal Taluk.

Sl. No.	Source	No. / Length	Net area irrigated (Ha)	Gross area irrigated (Ha)
1	Surface water	Canals	0	0
		Tanks	217	0
		Lift irrigation	1	43
2	Ground water	Dug Wells	2296	NA
		Bore wells	4129	3247
		Total	11814	3290

Source: District at a Glance 2016-2017, Govt. of Karnataka

1.6 Geomorphology, Physiography & Drainage

1.6.1 Geomorphology:

Geomorphologically, Anekal Taluk falls in southern maidan region. Physiographically, the area is characterized by undulating topography. It is located on a plateau and the highest elevation is observed at 940 m msl and the average elevation ranging from 600 to 900 m amsl. It has range of hills which are actually spurs of Eastern Ghats extends from east to south made up of granites with lateritic capping. **(Figure 2)**

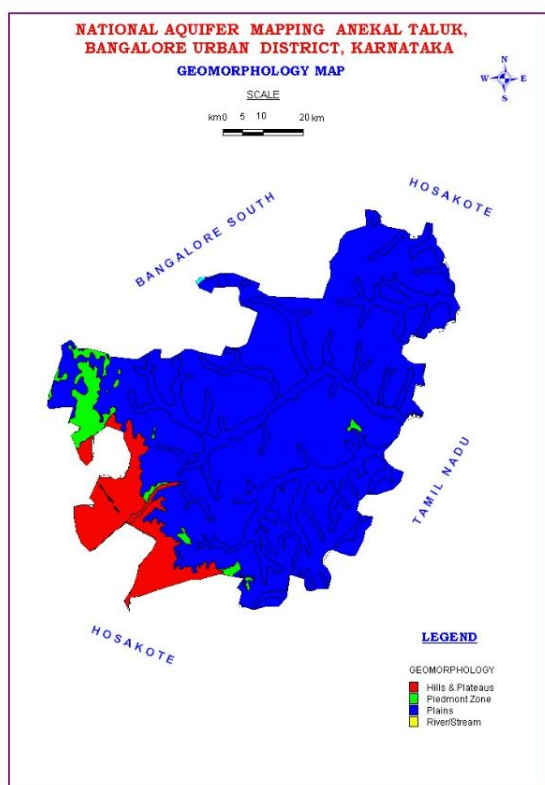


Figure 2: Geomorphology map

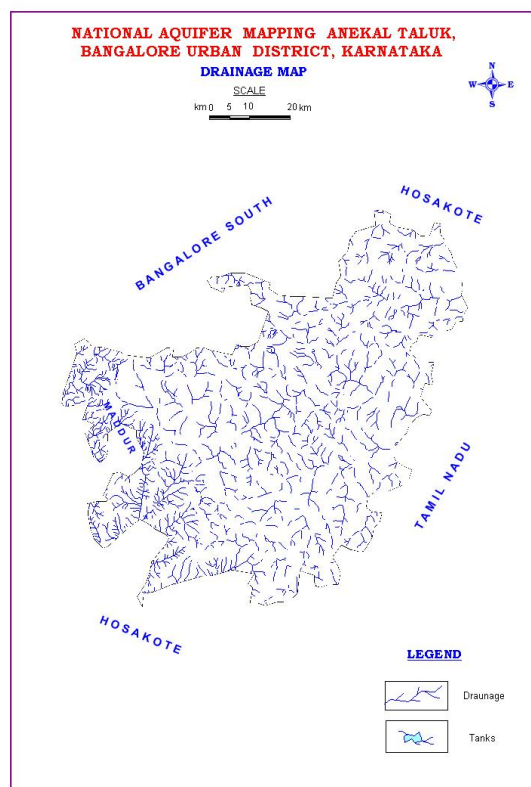


Figure 3: Drainage map

1.6.2 Drainage:

Anekal Taluk is the part of South Pennar (Ponnaiyar) river basin. The main drainage of the Taluk is from north to south. The South Pennar River which rises north of Sidlghatta Taluk at Nandi hills of Chickballapur district and after entering Bangalore Rural district/ Hosakote

towards southwards where it forms the large lake known as Janagama-Kote Kere and Hosakote-kere at Hosakote. The sewage waters of Bangalore city enter this river via Bellandur and Varthur lakes. The general drainage pattern is of sub-rectangular (**Figure 3**) due to marked influence of geologic structures in the basin.

1.7 Soil and Land Use

The soils of the area are derived from Gneiss, Granites and Laterites. Sandy, loam, black soil are the main soil types of the Taluk (**Figure 4**). The land use map (**Figure 5**) indicates that the major land use area is under agricultural activity, followed by forest and built-up/urban settlement areas.

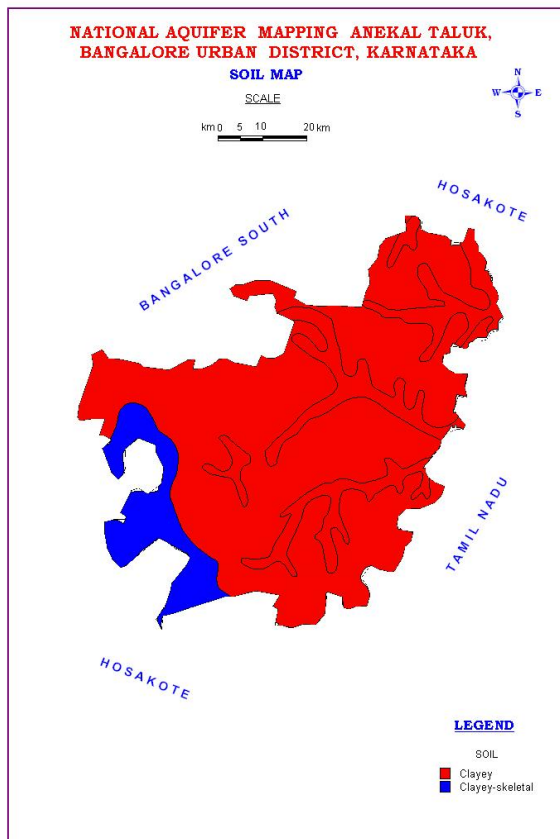


Figure 4 : Soil map

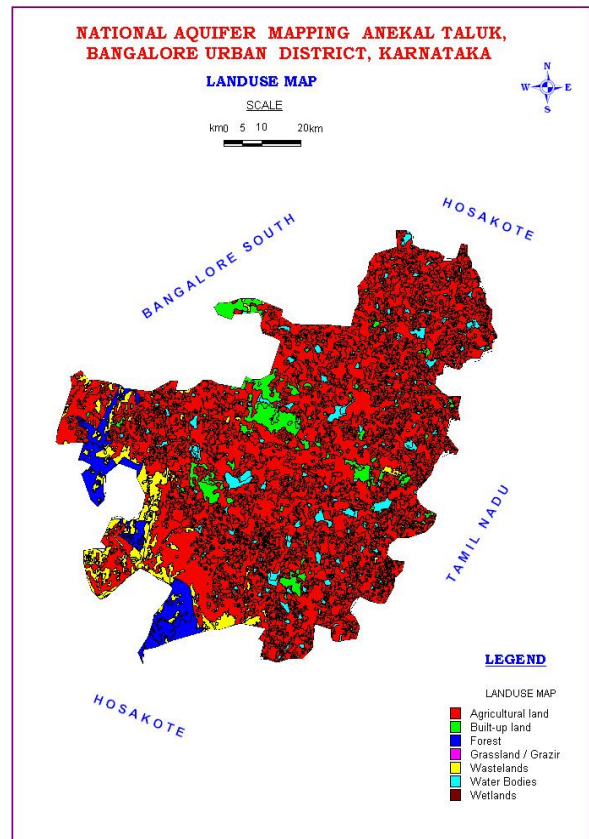


Figure 5 :Land use map

1.8 Geology

Anekal Taluk is occupied by Banded Gneisses called as Peninsular Gneissic Complex and small patch of laterite occurs north of Anekal (**Figure 6**).

1.9 Ground Water Resource Availability and Extraction

The ground water resources availability during 2017 & 2020 is presented in the **Table 6**. As per the estimation of 2017, the ground water draft (extraction) is worked out to be 5564 ham with stage of ground water extraction of 149%, whereas in 2020, the stage of ground water extraction was 167%.

Table 6: Ground Water Resource Estimation of Anekal Taluk – 2017 (Ham)

Year	Annual replenishable GW resources (ham)	Annual GW extraction (ham)	Stage of GW extraction (%)	Fresh In-storage GW resources (ham)		Total availability of fresh GW resources (ham)
				Phreatic	Fractured (Down to 200 m)	Dynamic +phreatic in-storage + fractured
2017	3739	5564	149	7647	1694	13080
2020	3180	5312	167	NA	NA	NA

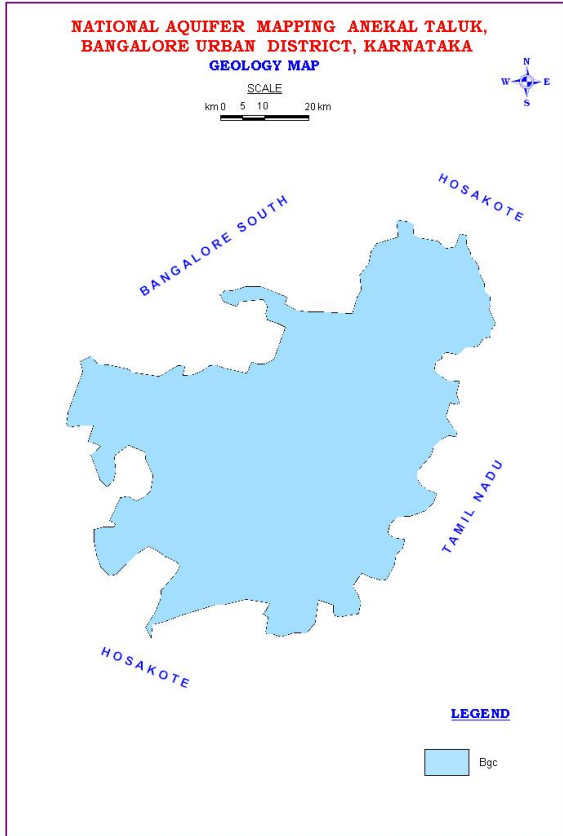


Figure 6 : Geology map

1.10 Existing and future water demands

As per GWRA 2020, existing ground water draft for irrigation, industrial & domestic (all use) is 5312 ham and as the stage of ground water development already reached up to 167% having nil availability for future irrigation demands. However, allocation of ground water for industrial and domestic purposes is computed to be 552 Ham.

1.11 Water level behavior

Phreatic aquifer is desaturated in most part of the Anekal Taluk. Change in average water levels of phreatic aquifer from 2014 to 2019 is furnished in **Table – 7**.

Table – 7: Average Depth to Water Level

2015		2016		2017		2018		2019	
No of Wells	WL (m bgl)	No of Wells	WL (m bgl)	No of Wells	WL (m bgl)	No of Wells	WL (m bgl)	No of Wells	WL (m bgl)
4	6.68	4	5.44	4	6.16	4	3.04	4	6.43

The depth to water levels during pre and post monsoon and the rate of fluctuation of water level are in the **Table 8** and depth to water level maps for pre and post monsoon are presented in **Figure 7** and **Figure 8** respectively. The perusal of the premonsoon DTW map indicates that major part of the area is occurring under 2 to 5 m bgl range, followed by more than 5 m bgl range. Shallow water levels of less than 2 mbgl are observed in small patch in south-western part of the taluk. In postmonsoon season, the water levels are spread over equal areas for 2-5 m bgl range and more than 5 m bgl range, whereas shallow water levels are observed in the same SW areas.

Table – 8: Depth to Water Level Data of Aquifer – I in Anekal Taluk

SITE NAME	DEPTH	RL (m amsl)	MP (m agl)	Aquifer Type	Depth to water level (m bgl)		Fluctuation (m)
					MAY2019	NOV2019	
Begihalli	6.60	900.66	0.00	Unconfined	3.45	1.62	1.83
Bhaktipura	12.00	924.54	1.67	Unconfined	10.75	4.83	5.92
Haragadde-A	11.35		0.80	Unconfined	6.75	5.70	1.05
Jigani	7.55		0.90	Unconfined	4.78	2.72	2.06

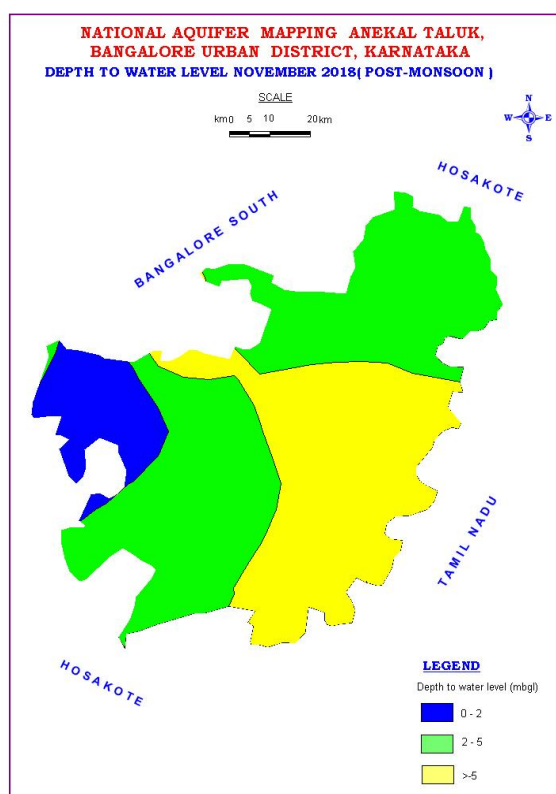
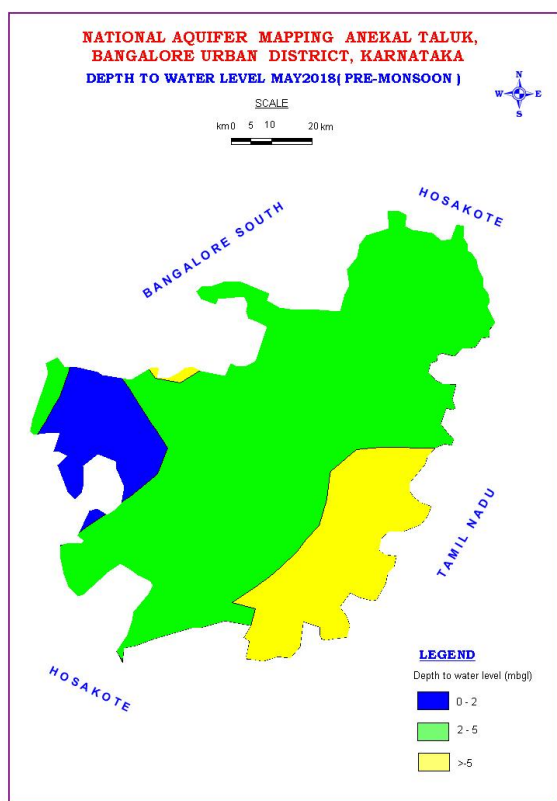


Figure 7 :Pre monsoon DTW Map Aquifer I Figure 8: Post monsoon DTW map Aquifer-I

Depth water level is also being monitored from 2 piezometers in Anekal taluk and the depth to water level data of the same is furnished below in the **Table 9**. It is observed that the water levels in the 2 Pz's show huge variation as the depths and zone encountered of both the Pz's are different.

Table-9: Depth to Water Level Data of Aquifer – II (Pz) in Anekal Taluk

SITE_NAME	DEPTH	MP	Aquifer Type	Depth to water level (m bgl)	
				MAY2019	NOV2019
Anekal	54.35	0.60	Semi Confined	21.97	19.74
CGWB Workshop	200.00	0.60	Semi Confined	2.50	2.41

The analysis of long-term water level trend in Aquifer-1 indicates that in pre-monsoon there is rising trend of 0.9098 m/year and falling trend of 0.0042 m/year. Similarly, during post monsoon there is a rising trend to the tune of 1.449 m/year and falling trend observed to be 1.0539 m/year. Overall trend indicates a falling trend to the tune of 1.6422 m/year.

2 AQUIFER DISPOSITION

The data collected during Geophysical investigation, Ground water exploration were made use to delineate the aquifer system, geometry and the extension of aquifer in terms of both lateral and vertical extent. The details of ground water exploration are presented in **Table 10.**

Table – 10: Details of Exploratory wells drilled in Anekal Taluk.

S.No	District	Location	EW	OW	Latitude	Longitude	Year of Drilling (FSP)	Depth Drilled (mbgl) / Casing Depth in m	Casing length	Lithology	Frac Zones in m	SWL in mbgl	APT Results	
													Q in LPS	DD in m
1	Bangalore Urban /Anekal	CGWB Division, Bommasandra	PZ		12.8142	77.6656	2011-12	200.2	15	Granitic Gneiss	68.68-70.32, 106.88-108.52, 137.44-139.08, 198.56-200.20	0.6	0.43	
2	Bangalore Urban /Anekal	SARJAPUR	EW		12.8611	77.7917	1992-93	172.29	18.24	GRGN PG	37,58-62,167, 170,172-79	20.88	1.41	6.23
3	Bangalore Urban /Anekal	SARJAPUR		OW	12.8611	77.7917		135	17.24	GRGN 9+2 Vein	28,83-89, 106-131		0.43	
4	Bangalore Urban /Anekal	ATTIBELE	EW		12.7806	77.7694	1992-93	241.37	31.26	PGMT GRGN. 9+2 vein	39.43,43,77-81, 104-106	24.815	2.8	12.6
5	Bangalore Urban /Anekal	ATTIBELE		OW	12.7806	77.7694	1992-93	205.27	26.2	PGMT GRGN. 9+2 vein	41,68-70, 80-81, 97-111	26.027	0.21	
6	Bangalore Urban /Anekal	CHANDAPURA			12.8028	77.7000	1992-93	203.27	15.24	GRGN	27,34,48,68.60, 111,120,136, 203.27	21.16	2.2	19.3
7	Bangalore Urban /Anekal	Muthsandra	EW		12.7521	77.7474	1992-93	200	24	Granitic Gneiss	152.72-154.36, 158.36-160.26, 188.92-190.92	110	4.2 cm	

8	Bangalore Urban /Anekal	Medihalli	EW		12.7126	77.6722	1992-93	200	27	Granitic Gneiss	DRY			
9	Bangalore Urban /Anekal	Bhaktipura	EW		12.7528	77.7667	1992-93	200	9	Granitic Gneiss	108.52-109.98, 186.92-187.96	12.98	4.5 cm	

2.1 Number of aquifers:

Based on the Ground water exploration data in Anekal Taluk, there are mainly two types of aquifer systems;

- i. Aquifer-I- (Phreatic aquifer) comprising **Weathered Gneiss / Granite** which is dry.
- ii. Aquifer-II- (Fractured multi-aquifer system) comprising Fractured **Gneiss / Granite**.

The basic characteristics of the two aquifers is given in **Table-11**, whereas the 2D, 3D aquifer disposition and aquifer geometry is furnished in **Fig 9 – 12**.

Table - 11: Basic characteristics of Aquifer- I and II

Sl. No.	Particulars	Aquifer-I (Desaturated in most of the parts)	Aquifer-II
1.	Aquifer	Weathered Gneisses	Fractured Gneisses
2.	Depth range in 'm'	9.00 to 32.00	135.00 to 240.00
3.	Weathering / Fractured in 'm'	5 to 15	100.00 to 203.00
4.	Yield in Ips	Negligible	0.21 to 2.80
5.	S.W.L. in m	4 to 6	0.60 to 110
6.	Transmissivity m ² /day	-	20 to 150
7.	EC (μS/cm at 25°C)	Generally, 300– 2250	80 -2200
8.	F(mg/l)	<1	<1
9.	NO ₃ (mg/l)	10 – 150 In more than 50 % area >45	5 -130

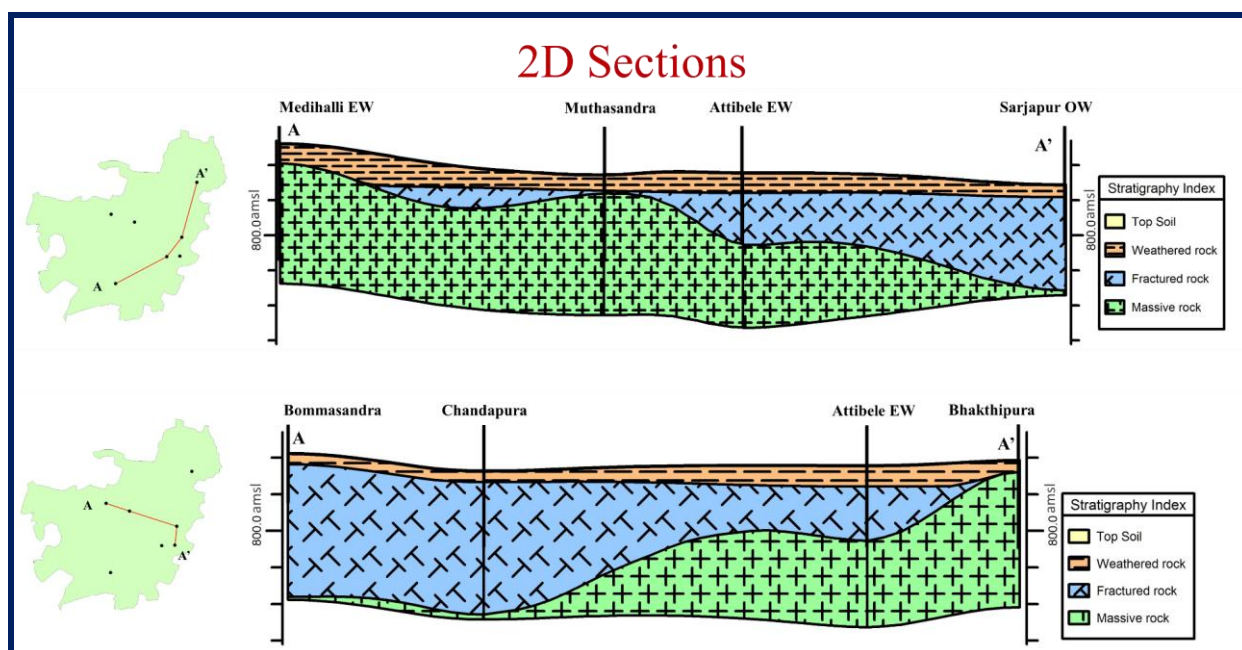


Fig. 9: 2D lithological sections

3D Aquifer Disposition

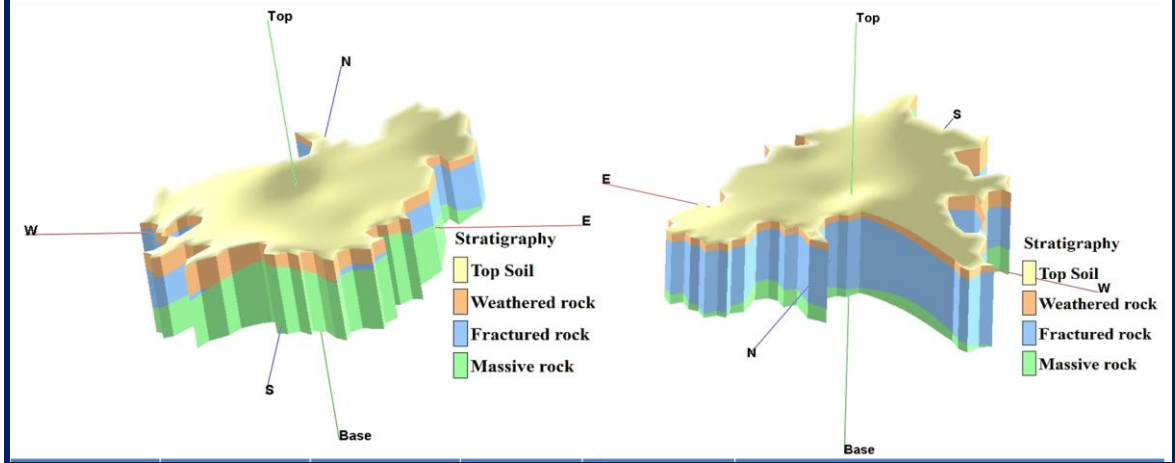


Fig. 10: 3D lithological sections

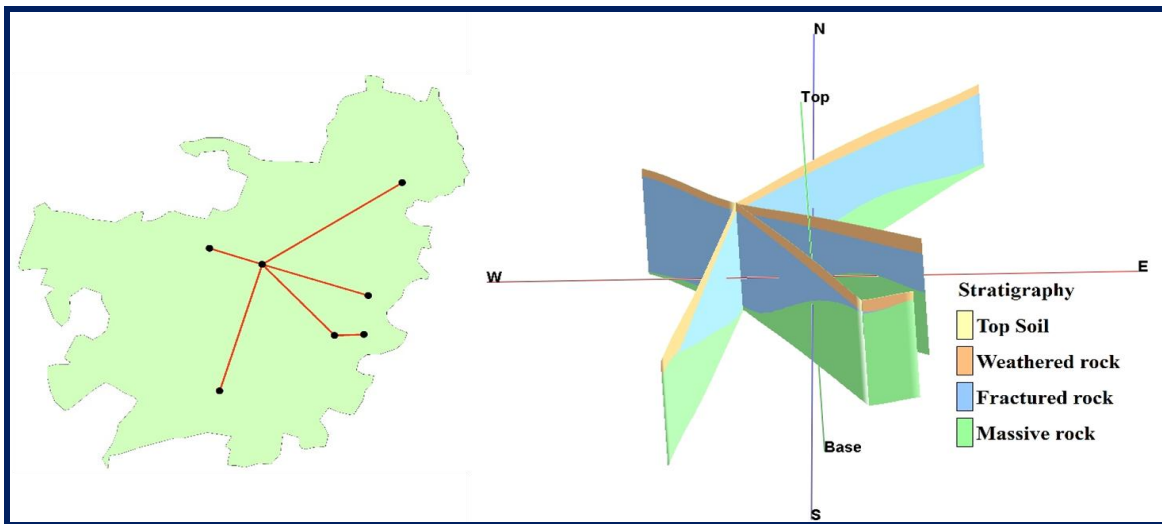


Fig.11: Fence Diagram

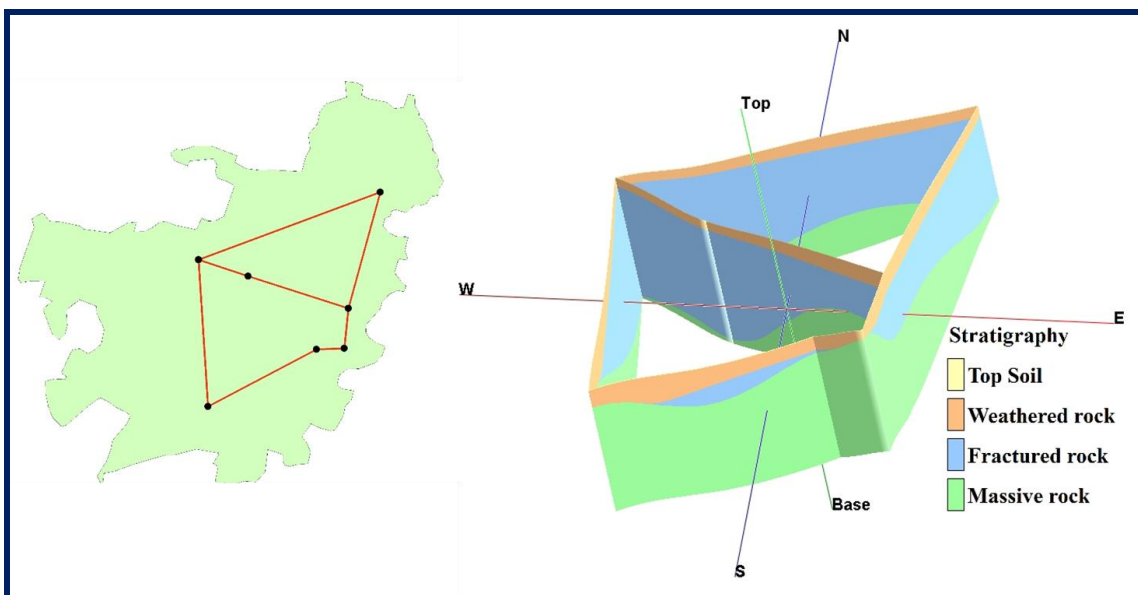


Fig.12: Fence Diagram

3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION ISSUES

The main ground water issues are urbanisation, less recharge worthy areas, over exploitation, limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, declining water level trend which are all inter-related or inter dependent and Inferior ground water quality due to nitrate contamination in some part of the area.

3.1 Aquifer wise resource availability and extraction:

The Dynamic Ground Water Resource 2017 and 2020 had been summarised and are shown in **Table 12**. The comparison of the resource as on 2013, 2017 and 2020 are presented below in **Table – 13**. It is observed that the ground water availability, extraction/draft and stage of development is increasingly continuously since 2013.

Table-12: Ground Water Resource of Anekal Taluk (2017 and 2020)

Assessment year	Net annual ground water Availability (ham)	Existing gross ground Water draft for irrigation (ham)	Existing gross ground Water draft for domestic (ham)	Existing gross ground Water draft for all uses (ham)	Allocation for domestic And industrial use for next 25 years (ham)	Net ground water Availability for future Irrigation development (ham)	Existing stage of ground Water development (%)	Category
As on March 2017	3738.97	5108.69	455.31	5564.00	455.31	0.00	149.00	Over Exploited
As on March 2020	3180.51	4834.34	478.51	5312.85	552.02	0.00	167.04	Over Exploited

Table 13: Comparison of groundwater availability and extraction scenario (in ham)

2013			2017			2020		
GW availability	GW Extraction	Stage of GW development	GW availability	GW Extraction	Stage of GW development	GW availability	GW Extraction	Stage of GW development
4504	6193	138%	3739	5564	149%	3180	5313	167%

3.2 Chemical quality / contamination of ground water

In general ground water in Anekal taluk is Sodium Chloride type. As per analysis the ground water from shallow aquifers is safe and potable. The summarized details of groundwater quality are presented in the **Table 14**, whereas the maps for EC, nitrate and Fluoride are presented in **Fig. 13, 14 and 15** respectively.

Table -14: GW Quality: in Anekal Taluk

Particulars	Phreatic Aquifer (Aquifer-I)	Fractured Aquifer (Aquifer-II)
EC ($\mu\text{S}/\text{cm}$ at 25°C)	300– 2250	80 -2200
F(mg/l)	<1	<1
NO ₃ (mg/l)	10 – 150 In more than 50 % area >45	5 -130

In Anekal taluk EC varies from 1000 to 2000 micromhos /cm at 25°C except for small part in the central part of Anekal taluk where salinity is more with EC > 2000 micromhos /cm at 25°C. The fluoride concentration is less than 1 mg/L thus rendering ground water suitable for drinking purpose. The nitrate concentration in 2 samples out of 5 samples is observed more than 45 mg/L rendering them unsuitable for drinking purpose.

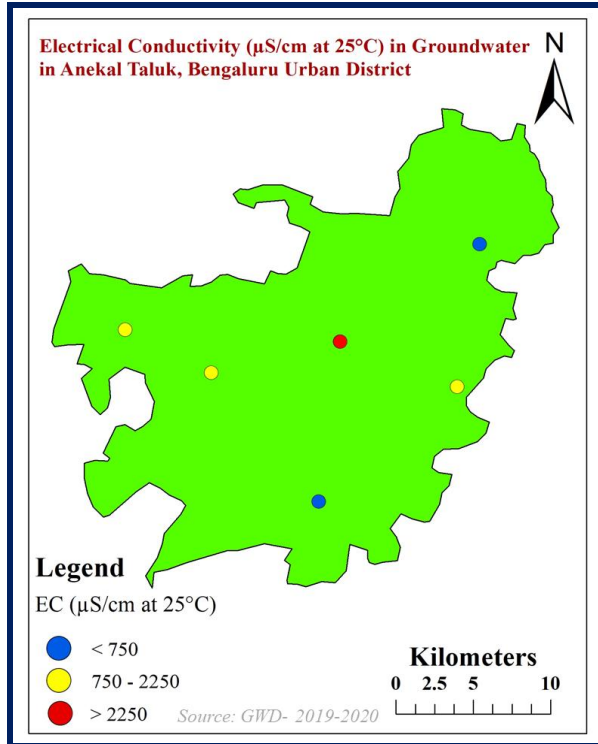


Fig.13: Distribution of EC

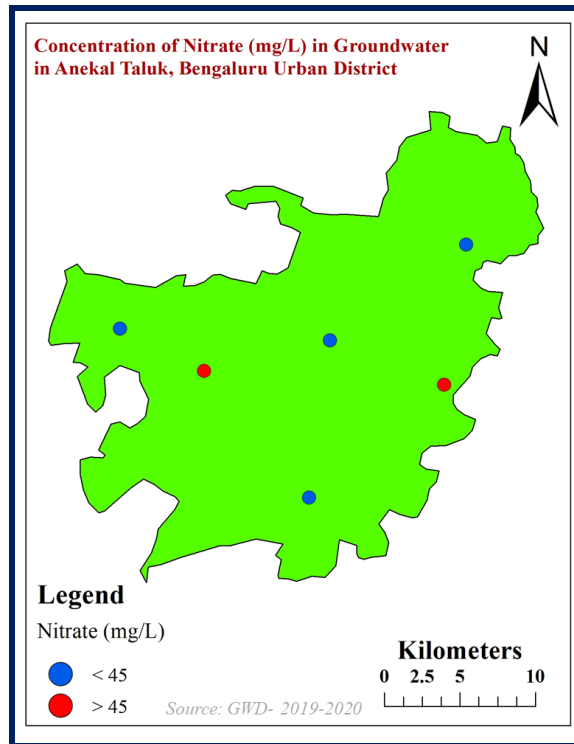


Fig.14: Distribution of Nitrate

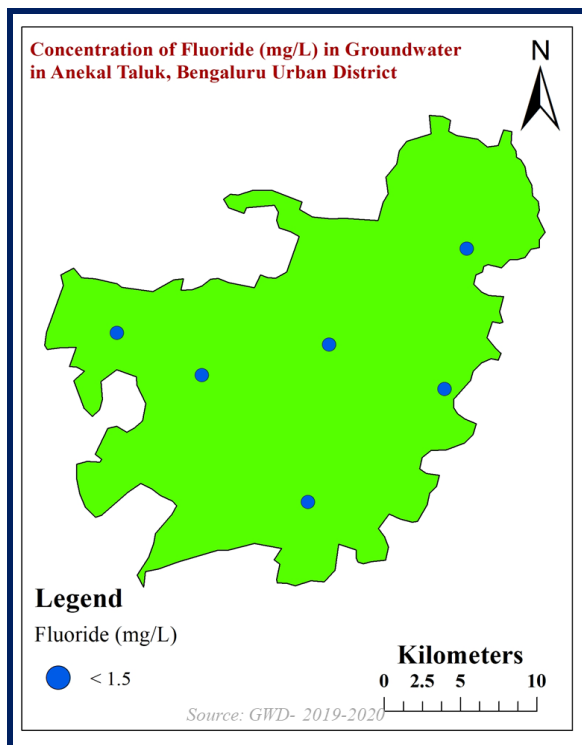


Fig.15: Distribution of Fluoride

4 GROUND WATER RESOURCE ENHANCEMENT

Continuous drought, increase in agricultural irrigation activity, subjected to excessive ground water withdrawal leading to depletion of ground water table, reduction in yield and deterioration of ground water quality etc., suggests a need for proper ground water management and enhancement of storage capacity of aquifers, protection of ground water quality and proper utilization of ground water.

To enhance the storage capacity of aquifers, the dewatered aquifers are to be recharged, for which the artificial recharge structures like Check dams, percolation tanks, point recharge structures etc., have to be constructed.

4.1 Resource Enhancement by Supply Side Interventions

The area feasible for recharge in Anekal taluk is worked out as 423 sq.km and the surface surplus non-committed runoff availability is 33.73 MCM, which is considered for planning of AR structures. For this, a total of 30 percolation tanks, 175 check dams and 6 filter bed structures are proposed. The volume of water expected to be conserved/recharged @75% efficiency is 12.75 MCM through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 2383.44 Lakhs. However, the figures given are tentative and pre-field studies / DPR are recommended prior to implementation of these recharge structures.

The details pertaining to proposed recharge structures, cost estimates and likely Recharge benefits for Anekal taluk have been carried out and given in below **Table 15**. The tentative locations of proposed AR structures and area feasible for recharge is shown in **Fig.- 16**, whereas the location details of proposed check dams, percolation tanks and filter beds are presented in **Annexure-I, II and III** respectively.

Table 15: Details of Proposed Supply Side Interventions in Anekal Taluk

Artificial Recharge Structures available/Proposed	Anekal Taluk
Non committed monsoon run off available (MCM)	33.73
Number of Check Dams Proposed	175
Number of Percolation Tanks Proposed	30
Number of Filter Beds Proposed	6
Tentative total cost of the project (Rs. In lakhs)	2383.44
Excepted recharge (MCM)	12.75

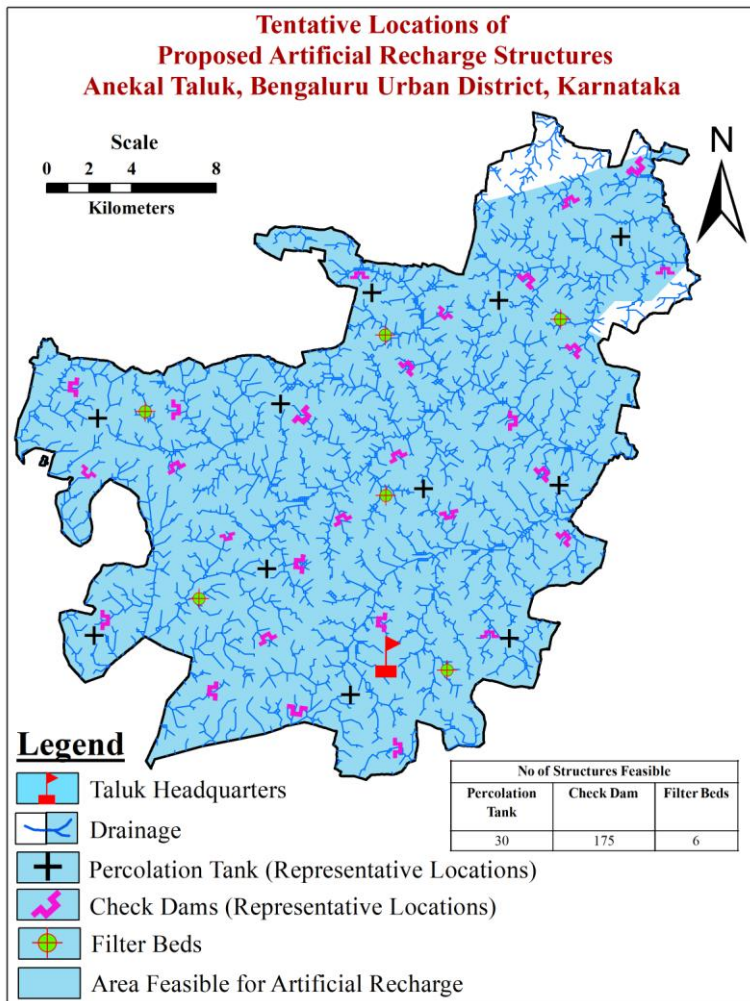


Fig.-16: Representative locations of proposed artificial recharge structures.

4.2 Resource Savings by Demand Side Interventions

4.2.1 Water Use Efficiency by Micro Irrigation Practices

It is observed that 4129 bore wells are the source for 4862 ha of net irrigation in the taluk constituting about 98% of the irrigated area. Adoption of water use efficiency (WUE) techniques will contribute in ground water resource enhancement in the long run by way of saving of water. Efficient irrigation practices like drip irrigation & sprinkler needs to be adopted by the farmers in the existing 4832 ha of net irrigated area by bore wells.

The water efficient methodology may be applied for irrigating fruits and vegetables which is largely ground water dependent. Also it is implemented in banana and coconut plantations. In long run the practice of efficient irrigation techniques will add to the ground water resource in large extent. Implementation of efficient irrigation techniques will contribute in saving ground water to the tune of 286 ham in respect to fruits and vegetables, 75 ham in case of banana plantation and 395 ham in coconut plantation. (**Table-16**).

4.2.2 Greywater Availability and its Management

Decentralized utilisation of grey water is effective way to ensure water use efficiency and integrated water resources management especially in overexploited areas like Anekal taluk where recharge from regular natural sources is not enough to sustain the ground water availability. It is relatively clean and cannot be compared with the water from toilets (blackwater). A total of 239 ham of grey water is reported to be available in Anekal taluk. Greywater can be reused for other purposes and does not necessarily have to be disposed of into the sewage system as other types of waste water.

Table 16: Details of Resource Enhancement after proposed demand side interventions

S. No.	Particulars	Values
1.	Crops proposed to be brought under micro irrigation	Fruits and Vegetables
2.	Fruits and Vegetables Cropped Area	4575 ha
3.	Considering 50% area irrigated by GW	2288 ha
4.	Crop Water Requirement by surface flooding	0.50 m
5.	Crop Water Requirement by drip	0.375 m
6.	Unit Savings	0.125 m
7.	Savings in crop water requirement	286 ham
8.	Savings in Perennial crop water requirement (Banana)	75 ham
9.	Savings in Perennial crop water requirement (Coconut)	395 ham
10.	Grey water Use gardening, construction, dust suppression etc	239 ham
11.	Total Savings	995 ham

This treated grey water can be repurposed for safe and beneficial uses such as gardening, construction, dust suppression etc. It, therefore, serves to substitute fresh water for some purposes thus allowing for water conservation as well as reducing the amount of water that is sent into the sewage system for treatment.

4.2.3 Change in cropping pattern

In Anekal taluk, the water intensive paddy crop is grown only in 83 ha area and major area is under Ragi which is primarily Kahrif rain-fed crop, hence change in cropping pattern is not suggested.

4.2.4 Additional area of irrigation

Urbanisation is one of the major problems. Irrigation areas are converted to buildup areas for households. Hence bringing additional area under irrigation may not be practical with a long-term resource management point of view.

4.3 Regulation and Control

The taluk has been categorized as Over-exploited, since the Stage of ground water development has reached 167% (GEC 2020). Hence, strict regulation has to be enforced by KGWA like protecting/notifying the deeper aquifers below 100 m depth for future drinking and domestic use so as to control the over exploitation of ground water in the Taluk. Ground water recharge component needs to be made mandatory in the taluk to save the situation from deteriorating further. Many of bore wells registered as irrigation wells are being used for domestic consumption in peripheral areas. Hence, metering of wells and ground water abstraction charges are recommended under regulation.

4.4 Other Interventions proposed:

- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- Excess nitrate concentration is found in ground water samples which require remedial measures viz. dilution of nitrate rich ground water through artificial recharge & water conservation.
- Build up awareness among local village community about proper disposal of sewage/runoff from chemical fertilizers contributing to nitrate
- Mandatory roof top rain water harvesting in urban and semi-urban areas.
 - All upcoming, large residential apartment complexes and industries should build two water supply systems for daily use, one for normal water and another for treated grey water.
 - Scientific disposal of sewage water by the concerned agency.

5 SUMMARY OF RECOMMENDATIONS

The main ground water issues are urbanisation, less recharge worthy areas, over exploitation, limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, declining water level trend which are all inter-related or inter dependent and Inferior ground water quality due to nitrate contamination in major part of the area. The summary of ground water management plan of the taluk is given in **Table-17**.

Table 17: Summary of Management plan of Anekal taluk

Stage of GW Extraction and Category (2020)	167 %, Over Exploited
Annual Extractable GW Resource (Ham)	3180.51
Total Extraction (Ham)	5312.85
Ground Water Draft for Irrigation (Ham)	4834.34
Ground Water Resource Enhancement by Supply side Interventions	
Non committed monsoon run off available (ham)	3373
No of Proposed AR structures	
SSD	0
PT	30
CD	175
FB	6
Expected Additional Recharge to GW due to AR (Ham)	1275
Additional Irrigation Potential that can be created (Ha)	Not suggested
Total Estimated Expenditure (Rs. in lakhs)	2383.44
Ground Water Resource Savings by Demand side Interventions	
Fruits, Vegetables, Banana and Coconut area suggested to be brought under micro irrigation	2702 ha
Expected Saving due to adopting WUE (Ham)	756
Expected Saving due to adopting grey water use (Ham)	239
Change in Cropping Pattern	Not Suggested
Change in Stage of GW development (%)	167 to 97.5
Ground Water Quality – Nitrate contamination	Improving quality by proper drainage of sewage and Limited usage of Nitrogenous fertilizers
Ground Water Regulation	Strict regulation has to be enforced by KGWA like protecting/notifying the deeper aquifers below 100 m depth for drinking and domestic use.

As per the resource estimation – 2020, Anekal taluk falls under Over-exploited category with the stage of ground water extraction is 167%. Thus, there is need to formulate management strategy to tackle the urbanisation, over-exploitation, water scarcity related issues in the taluk on urgent basis. It is suggested to adopt a scientific and multi-pronged ground water management strategy covering supply side interventions, demand side interventions, ground water regulation interventions and ground water quality protection aspects as mentioned in the management plan suggested above

Ground water resource enhancement by supply side interventions: Quantity of surface water available through non-committed surface run-off is estimated to be 3373 ham. This can be used to recharge the aquifer mainly through percolation tanks (30) and check dams (175) and point recharge structures (6). The volume of water expected to be conserved/recharged @ 75% efficiency is 1275 ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 2383.44 lakhs. However, the figures given are tentative and pre-field studies / DPR are recommended prior to implementation of these recharge structures. Since this taluk falls in the vicinity of the rapidly growing Bangalore city, it may not possible to bring additional area under irrigation. Roof top rain water harvesting should be made mandatory in urban and semi-urban areas and the rain water harvested from each building should be stored in-situ and used /mixed with surface water supply or ground water.

Ground water resource enhancement by demand side interventions: At present maximum irrigation is by bore wells (ground water). The micro irrigation practices like drip and sprinkler irrigation are practiced to less extent in comparison with traditional mode of irrigation. Implementation of efficient irrigation techniques in 2702 ha of fruits, vegetables, banana and coconut grown area will contribute in saving ground water by 756 ham.

Greywater Availability and its Management: A total of 239 ham of grey water is reported to be available in Anekal taluk. Greywater can be reused for other purposes and does not necessarily have to be disposed of into the sewage system as other types of waste water. It is also recommended to explore the feasibility to fill up tanks by making use of treated sewage water after eliminating industrial effluents and heavy metals.

Ground Water Regulation: The taluk has been categorized as Over-exploited, since the Stage of ground water development has reached 167% (GEC 2020). Hence, strict regulation has to be enforced by KGWA like protecting/notifying the deeper aquifers below 100 m depth for future drinking and domestic use so as to control the over exploitation of ground water in the Taluk.

Continuation of augmenting surface water supply (import) from Cauvery river source to reduce stress on ground water.

Annexure-I: Tentative location of Proposed Percolation Tanks, Anekal Taluk, Bangalore Urban District.

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
1	77.72678	12.69050	J.I.Guddahalli	Samanduru	Anekal
2	77.68337	12.69488	Sunnavaara	Vanakanahalli	Anekal
3	77.62941	12.70331	Thammanayakanahalli	Indlawadi	Anekal
4	77.75264	12.71820	Samanduru	Samanduru	Anekal
5	77.57225	12.72117	Shivanahalli	Ragihalli	Anekal
6	77.66655	12.72804	K.G.Sonnayakanapura	Suragajakkanahalli	Anekal
7	77.63228	12.73388	Indlavadi	Indlawadi	Anekal
8	77.70716	12.73480	Chikkahagade	Byagadadenahalli	Anekal
9	77.64766	12.74890	Nosenuru	Haragadde	Anekal
10	77.68325	12.75297	Doddahegade	Byagadadenahalli	Anekal
11	77.60984	12.75370	K.G.Mahantha Lingapura	Kallubalu	Anekal
12	77.77276	12.75527	Balluru	Balluru	Anekal
13	77.61185	12.78205	Bukkasagara	Kallubalu	Anekal
14	77.71607	12.78239	Madiwala	Marasuru	Anekal
15	77.77489	12.78321	Attibele	Anekal	Anekal
16	77.74206	12.78750	Yadavanahalli	Neraluru	Anekal
17	77.66993	12.79478	Hennagara	Hennagara	Anekal
18	77.73568	12.80549	Guddahatti	Neraluru	Anekal
19	77.57473	12.81379	Bannerughatta	Bannerughatta	Anekal
20	77.67626	12.81757	Hebbagodi	Anekal	Anekal
21	77.65436	12.81923	Hulimangala	Hulimangala	Anekal
22	77.62222	12.82099	Hullahalli	Mantapa	Anekal
23	77.70633	12.82838	Andhapura	Anekal	Anekal
24	77.77463	12.83672	Bikkanahalli	Handenahalli	Anekal
25	77.74957	12.86232	Kammasandra	Muththanalluru	Anekal
26	77.69456	12.86624	Gettehalli	Shantipura	Anekal
27	77.80297	12.88900	Koothaganahalli	Muguluru	Anekal
28	77.74451	12.88962	Dommasandra	Dommasandra	Anekal
29	77.78555	12.89922	Gonigattapura	Neriga	Anekal
30	77.76752	12.89989	Nerige	Neriga	Anekal

Annexure-II: Tentative location of Proposed Check Dams, Anekal Taluk, Bangalore Urban District.

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
1	77.70357	12.67252	Menasiganahalli	Vanakanahalli	Anekal
2	77.68410	12.67348	Kalanayakanahalli	Vanakanahalli	Anekal
3	77.72453	12.68416	J.I.Guddahalli	Samanduru	Anekal
4	77.64254	12.68460	Thammanayakanahalli	Indlawadi	Anekal
5	77.69493	12.68484	Singasandra	Vanakanahalli	Anekal
6	77.62736	12.68571	Thammanayakanahalli	Indlawadi	Anekal
7	77.65933	12.68807	Thammanayakanahalli	Indlawadi	Anekal
8	77.70358	12.69240	Hampalagatta	Samanduru	Anekal
9	77.62308	12.69672	Thammanayakanahalli	Indlawadi	Anekal
10	77.72664	12.70020	Sabmangala	Samanduru	Anekal
11	77.68129	12.70276	Anekal	Anekal	Anekal
12	77.65049	12.70344	Chikkahosahalli	Indlawadi	Anekal
13	77.75980	12.70459	Samanduru	Samanduru	Anekal
14	77.68972	12.70803	Anekal	Anekal	Anekal
15	77.63294	12.70827	Indlavapura	Indlawadi	Anekal
16	77.65993	12.70852	Chikkahosahalli	Indlawadi	Anekal
17	77.73520	12.70873	Channena Agrahara	Samanduru	Anekal
18	77.56496	12.70945	Shivanahalli	Ragihalli	Anekal
19	77.70864	12.71052	Kurubarahatti	Samanduru	Anekal
20	77.62100	12.71234	Indlavapura	Indlawadi	Anekal
21	77.58125	12.71811	Shivanahalli	Ragihalli	Anekal
22	77.67291	12.71833	A.Medahalli	Suragajakkanahalli	Anekal
23	77.64584	12.71980	Thimmasandra	Indlawadi	Anekal
24	77.74415	12.72029	Rachamanahalli	Karpur	Anekal
25	77.61633	12.72158	J.I.Begganadoddi	Indlawadi	Anekal
26	77.56379	12.72545	Shivanahalli	Ragihalli	Anekal
27	77.67725	12.72576	Honnakalashapura	Suragajakkanahalli	Anekal
28	77.69654	12.72613	Chikkahagade	Byagadadenahalli	Anekal
29	77.63038	12.72623	Indlavadi	Indlawadi	Anekal
30	77.72505	12.72706	Bestamanahalli	Karpur	Anekal
31	77.57823	12.72814	Shivanahalli	Ragihalli	Anekal
32	77.60145	12.72903	K.G.Mahantha Lingapura	Kallubalu	Anekal
33	77.61972	12.73028	J.I.Begganadoddi	Indlawadi	Anekal
34	77.65843	12.73073	K.G.Adhuru	Suragajakkanahalli	Anekal
35	77.75532	12.73177	Halehalli	Balluru	Anekal
36	77.60877	12.73770	K.G.Mahantha Lingapura	Kallubalu	Anekal
37	77.58686	12.73822	Ragihalli	Ragihalli	Anekal
38	77.64684	12.73861	Nosenuru Gollahalli	Haragadde	Anekal
39	77.62292	12.74034	Kadachikkanahalli	Indlawadi	Anekal
40	77.66256	12.74061	Suragajakkanahalli	Suragajakkanahalli	Anekal
41	77.68603	12.74174	Kempavaderahalli	Byagadadenahalli	Anekal
42	77.70532	12.74259	Kammasandra Agrahara	Byagadadenahalli	Anekal
43	77.73498	12.74488	Thatnahalli	Byagadadenahalli	Anekal

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
44	77.75547	12.74581	Kodalipura	Balluru	Anekal
45	77.65281	12.74632	Nosenuru	Haragadde	Anekal
46	77.77346	12.74920	Dasanapura	Balluru	Anekal
47	77.66121	12.75066	Kumbaranahalli	Haragadde	Anekal
48	77.61958	12.75144	Giddenahalli	Kallubalu	Anekal
49	77.69770	12.75178	Koonamadiwala	Byagadadenahalli	Anekal
50	77.64039	12.75182	Bommandahalli	Kallubalu	Anekal
51	77.67519	12.75320	Soppahalli	Byagadadenahalli	Anekal
52	77.60255	12.75480	K.G.Mahantha Lingapura	Kallubalu	Anekal
53	77.76389	12.75490	Bhaktipura	Mayasandra	Anekal
54	77.70936	12.76062	Marasuru	Marasuru	Anekal
55	77.77785	12.76111	Balluru	Balluru	Anekal
56	77.63028	12.76173	Konasandra	Kallubalu	Anekal
57	77.61663	12.76183	K.G.Mahantha Lingapura	Kallubalu	Anekal
58	77.66101	12.76470	Haragaddhe	Haragadde	Anekal
59	77.67994	12.76989	Hennakki	Hennagara	Anekal
60	77.72712	12.77030	Madiwala	Marasuru	Anekal
61	77.64807	12.77048	Haragaddhe	Haragadde	Anekal
62	77.69304	12.77155	Marasuru	Marasuru	Anekal
63	77.56295	12.77178	Bannerughatta	Bannerughatta	Anekal
64	77.74419	12.77222	Icchanguru	Neraluru	Anekal
65	77.63013	12.77275	Kallubalu	Kallubalu	Anekal
66	77.60336	12.77421	Bukkasagara	Kallubalu	Anekal
67	77.76250	12.77680	Attibele	Anekal	Anekal
68	77.70436	12.77681	Iggaluru	Anekal	Anekal
69	77.78107	12.77691	Attibele	Anekal	Anekal
70	77.75246	12.77868	K.G.Krishnasagara	Neraluru	Anekal
71	77.68248	12.77916	Hennakki	Hennagara	Anekal
72	77.64213	12.78488	Jigani	Anekal	Anekal
73	77.59690	12.78639	Mantapa	Mantapa	Anekal
74	77.67767	12.78778	Hennagara	Hennagara	Anekal
75	77.66420	12.78870	Rajapura	Hennagara	Anekal
76	77.62706	12.78878	Harapanahalli	Kallubalu	Anekal
77	77.76864	12.78890	Indlabele	Bidaraguppe	Anekal
78	77.71787	12.78952	Thirumagondanahalli	Neraluru	Anekal
79	77.57075	12.79023	Byrappanahalli	Bannerughatta	Anekal
80	77.72553	12.79183	Neraluru	Neraluru	Anekal
81	77.58813	12.79245	Mantapa	Mantapa	Anekal
82	77.60823	12.79345	K.G.Bigihalli	Mantapa	Anekal
83	77.78095	12.79364	Indlabele	Bidaraguppe	Anekal
84	77.74260	12.79404	Yadavanahalli	Neraluru	Anekal
85	77.62429	12.79525	Harapanahalli	Kallubalu	Anekal
86	77.64692	12.79545	Bande Nallasandra	Anekal	Anekal
87	77.65416	12.79558	Bande Nallasandra	Anekal	Anekal
88	77.70518	12.79682	Iggaluru	Anekal	Anekal

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
89	77.76394	12.79740	Jigala	Bidaraguppe	Anekal
90	77.79883	12.79914	Bidarakuppe	Bidaraguppe	Anekal
91	77.74042	12.79972	Guddahatti	Neraluru	Anekal
92	77.55981	12.80186	Bhoothanahalli	Bannerughatta	Anekal
93	77.57300	12.80216	Bannerughatta Shankarikavalu	Bannerughatta	Anekal
94	77.58642	12.80382	Bannerughatta	Bannerughatta	Anekal
95	77.54471	12.80453	Bhoothanahalli	Bannerughatta	Anekal
96	77.65557	12.80731	Vabasandra	Hulimangala	Anekal
97	77.68904	12.80895	Bommasandra	Anekal	Anekal
98	77.72802	12.80974	Lakshmisagara	Anekal	Anekal
99	77.64454	12.81047	Nanjapura	Hulimangala	Anekal
100	77.79074	12.81088	Bidarakuppe	Bidaraguppe	Anekal
101	77.74234	12.81138	Bendiganahalli	Neraluru	Anekal
102	77.75635	12.81184	Hadigondanahalli	Neraluru	Anekal
103	77.55006	12.81271	Bhoothanahalli	Bannerughatta	Anekal
104	77.56215	12.81302	Bhoothanahalli	Bannerughatta	Anekal
105	77.66564	12.81307	Hyarandahalli	Hennagara	Anekal
106	77.77099	12.81437	Arenuru	Bidaraguppe	Anekal
107	77.59414	12.81450	Halesampigenahalli	Mantapa	Anekal
108	77.70036	12.81481	Bommasandra	Anekal	Anekal
109	77.62765	12.81596	S.I Bangipura	Hulimangala	Anekal
110	77.60969	12.81704	Hullukasavenahalli	Mantapa	Anekal
111	77.71474	12.82063	Hellalige	Anekal	Anekal
112	77.67110	12.82263	Hebbagodi	Anekal	Anekal
113	77.64478	12.82356	Hulimangala	Hulimangala	Anekal
114	77.59362	12.82377	Lakshmipura	Mantapa	Anekal
115	77.68189	12.82396	Hebbagodi	Anekal	Anekal
116	77.57962	12.82421	Bannerughatta	Bannerughatta	Anekal
117	77.74918	12.82476	Sollepura	Handenahalli	Anekal
118	77.78817	12.82644	S.Modihalli	Handenahalli	Anekal
119	77.56351	12.82645	Bilvaradhahalli	Bannerughatta	Anekal
120	77.73094	12.82704	Muttanalluru	Muththanalluru	Anekal
121	77.66248	12.82786	Maragondanahalli	Hulimangala	Anekal
122	77.62018	12.82978	Hullahalli	Mantapa	Anekal
123	77.76660	12.83025	K.G. Kutaganahalli	Handenahalli	Anekal
124	77.78001	12.83130	S.Modihalli	Handenahalli	Anekal
125	77.63207	12.83145	S.I Bangipura	Hulimangala	Anekal
126	77.65170	12.83379	Maragondanahalli	Hulimangala	Anekal
127	77.71001	12.83443	Singena Agrahara	Muththanalluru	Anekal
128	77.75083	12.83609	Samenahalli	Muththanalluru	Anekal
129	77.55144	12.83763	Kannaiakana Agrahara	Bannerughatta	Anekal
130	77.67902	12.84012	K.G.Veerassandra	Anekal	Anekal
131	77.78347	12.84143	Bhoragunte	Billapura	Anekal
132	77.76537	12.84355	Hosahalli	Yamare	Anekal
133	77.69915	12.84410	Gulimangala	Huskuru	Anekal

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
134	77.73494	12.84459	Gopasandra	Muththanalluru	Anekal
135	77.72139	12.84506	Narayanagatta	Muththanalluru	Anekal
136	77.75612	12.84679	Hosahalli	Yamare	Anekal
137	77.74670	12.84809	Chikkathimmasandra	Muththanalluru	Anekal
138	77.68856	12.84959	Chikkanagamangala	Shantipura	Anekal
139	77.77504	12.85078	Chikkadunnasandra	Yamare	Anekal
140	77.76385	12.85717	Hosahalli	Yamare	Anekal
141	77.72579	12.85727	Kaggalipura	Huskuru	Anekal
142	77.75677	12.85984	Kada Agrahara	Yamare	Anekal
143	77.69066	12.86118	Chikkanagamangala	Shantipura	Anekal
144	77.74350	12.86216	Kammasandra	Muththanalluru	Anekal
145	77.70575	12.86315	Huskuru	Huskuru	Anekal
146	77.78024	12.86686	Sarjapura	Sarjapura	Anekal
147	77.72319	12.87044	Chokkasandra	Huskuru	Anekal
148	77.76325	12.87207	Yamare	Yamare	Anekal
149	77.80446	12.87252	Mahal Chowdadenahalli	Muguluru	Anekal
150	77.68912	12.87348	K.G.Sriramapura	Shantipura	Anekal
151	77.74504	12.87411	Dommasandra	Dommasandra	Anekal
152	77.82183	12.87444	Pandithana Agrahara	Muguluru	Anekal
153	77.70825	12.87456	Avalahalli	Shantipura	Anekal
154	77.78026	12.87816	Valagere Kallahalli	Yamare	Anekal
155	77.67991	12.87835	Rayasandra	Shantipura	Anekal
156	77.81511	12.88331	Doddathimmasandra	Muguluru	Anekal
157	77.74300	12.88350	Dommasandra	Dommasandra	Anekal
158	77.79953	12.88462	Koothaganahalli	Muguluru	Anekal
159	77.68147	12.88741	K.G.Choodasandra	Shantipura	Anekal
160	77.77423	12.88795	Valagere Kallahalli	Yamare	Anekal
161	77.75085	12.88858	Thigalachowdadenahalli	Yamare	Anekal
162	77.82493	12.89009	Mugaluru	Muguluru	Anekal
163	77.65983	12.89146	Kudlu	Anekal	Anekal
164	77.78656	12.89222	Chikkadasarahalli	Neriga	Anekal
165	77.76279	12.89343	Chambenahalli	Yamare	Anekal
166	77.80257	12.89511	Koothaganahalli	Muguluru	Anekal
167	77.74509	12.89648	Chikkavaderapura	Neriga	Anekal
168	77.75667	12.90401	Ramanayakanahalli	Neriga	Anekal
169	77.79897	12.90451	Chikkanahalli Kamanahalli	Muguluru	Anekal
170	77.78066	12.90490	Nerige	Neriga	Anekal
171	77.81732	12.90642	Banahalli	Muguluru	Anekal
172	77.77270	12.90785	Nerige	Neriga	Anekal
173	77.78850	12.90941	Gonigattapura	Neriga	Anekal
174	77.79982	12.91062	Chikkanahalli Kamanahalli	Muguluru	Anekal
175	77.81081	12.91701	Kuguru	Muguluru	Anekal

Annexure-III: Tentative location of Proposed Filter Beds, Anekal Taluk, Bangalore Urban District.

S. No	Longitude	Latitude	Village	Gram Panchayath	Taluk
1	77.72553	12.70499	Muttugatti	Samanduru	Anekal
2	77.61810	12.73645	Kadachikkanahalli	Indlawadi	Anekal
3	77.69965	12.77962	Iggaluru	Anekal	Anekal
4	77.59553	12.81649	Lakshmipura	Mantapa	Anekal
5	77.70021	12.84804	Gulimangala	Huskuru	Anekal
6	77.77632	12.85397	Chikkadunnasandra	Yamare	Anekal