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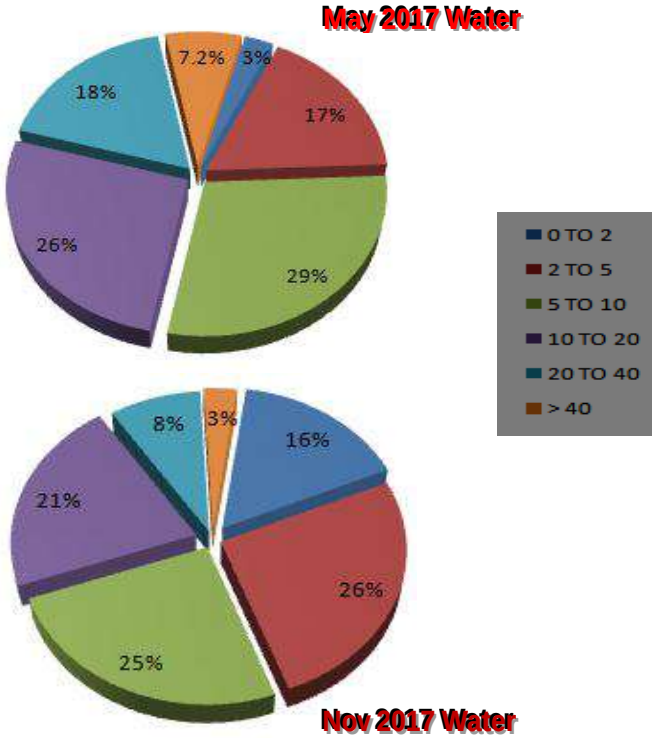
Central Ground Water Board

Ministry of Water Resources,
River Development & Ganga Rejuvenation
Govt. of India

GROUND WATER YEAR BOOK
2017-18
ANDHRA PRADESH



Hyderabad

June, 2018

Central Ground Water Board

Ministry of Water Resources,
River Development & Ganga Rejuvenation
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GROUND WATER YEAR BOOK
2017-2018
ANDHRA PRADESH STATE

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GROUND WATER YEAR BOOK
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ANDHRA PRADESH STATE

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FOREWORD

The historical ground water level monitoring data is useful in understanding changes in ground water regime in time and space and for preparation of sustainable development plan for the state. Central Ground Water Board has been monitoring ground water regime since 1969. As on 31-3-2018, a total of 865 operational ground water monitoring wells (GWMS) (DW: 717, Pz: 148) are in operations. These stations are being monitored four times a year viz., May, August, November and January to study the seasonal and long term changes. The water samples are collected during May for chemical analysis.

The ground water level monitoring carried out by Central Ground Water Board, Southern Region, Hyderabad during 2017-18 is compiled in the form of Ground Water Year Book. It outlines the ground water level behavior in the current year with reference to the corresponding periods of previous year and also with last decadal mean. It also elaborates the chemical quality of ground water.The water level data of state Ground Water Department has also been considered to study the water level behavior. It also elaborates the chemical quality of ground water.

The sincere efforts made by **Sri. P.Sudhakar, Scientist-D (HM) and G Praveen Kumar, Sc-C(AHg)** in preparation of the report are commendable. The efforts from officers of chemical laboratory namely Shri K. Bhaskar Reddy, Shri K. Maruthi Prasad and Shri Y. Satyakumar who analyzed the samples and contributed ground water quality chapter is note worthy. The efforts of Dr.P.N.Rao, Suptg.HG in scrutiny of the report , Shri GRC Reddy, Scientist-D and S.Renuka, Scientist-B (GP) of Report Processing Section in processing and issuance of the report are also appreciated.

It is hoped that the Ground Water Year Book will be quite useful as baseline information for planners, administrators and researchers involved in ground water development and management in the state of Telangana.

Hyderabad **(D Subba Rao)**
Dated: 28-5-2018 **Regional Director**

EXECUTIVE SUMMARY

Andhra Pradesh State with geographical area of 1.63 lakh sq.km, is governed administratively by 13 districts. The total population of the State is 4.96 crores with a decadal growth of 9.2%. It lies between North Longitude 12° 37' and 19° 09' and East Latitude 76° 45 ' and 84° 47'. The State is mainly drained by Godavari, Krishna, Pennar, Vamsadhara, Nagavalli, Gundlakamma rivers. A major part of the area is underlain by hard rock formations comprising gneissic rocks, Eastern ghats and meta-sediments. During the year 2017, the state received annual rainfall in the range of 589 mm (Anantapuramu district) to 1274 mm (Srikakulam district) with average of 898 mm.

As part of National Ground Water Monitoring Programme, Central Ground Water Board (CGWB) is carrying out ground water regime monitoring 4 times a year (January, May, August and November) and ground water quality 1 time (May). As on 31.03.2018, total of 875 Ground Water Monitoring Wells are in existence while 151 wells are monitored on participatory mode. Ground water levels data base help in groundwater management particularly in the context of large scale contemplated surface water command areas in the state. For the first time, Ground Water Year Book is compiled based on integrated data generated by CGWB and Ground Water Department, Govt. of Andhra Pradesh in order to have realistic ground water scenario.

Water level analysis shows that during pre-monsoon season, water levels are shallow in canal command areas particularly in deltaic areas and deep water level in non-command areas. Annual water level fluctuation of May 2016 vs May 2017 has shown rise in water levels in 35 % of the area, predominantly in Prakasam, Guntur, East Godavari and West Godavari, and parts of Anantapuramu, Kurnool and Kadapa districts inspite of less rainfall in 2016 monsoon in comaprision with 2015 monsoon, except in Prakasam district.

During May 2017, deeper water levels of more than 10 m are noticed in Rayalaseema region and Prakasam districts, where ground water is the main source for irrigation. Rise in water levels in Nov 2017 is observed in the entire state from May 2017 , except in Prakasam, Krishna, Nellore and Anantapuramu district. Shallow water level in the range of 0 to 2 m bgl observed in 13% of the area mostly in coastal belt and small parts of Kurnool district. Deep water levels in the range of more than 20 mbgl observed in small parts of Kadapa, Anantapuramu, Kurnool, Prakasam and Guntur districts. Long term water level behavior (1998-2017) indicates that falling trend is observd in 81% of the area (0 to 6 m /yr) and rising trend in 19% of the area (0 to 3 m/yr).

Ground water quality of 600 samples during pre-monsoon season of 2017 were analysed for major constituents. Fluoride concentration varies from 0.09-3.82 mg/l and found that 7% samples are unfit for human consumption.

GROUND WATER YEAR BOOK
(2017–2018)
ANDHRA PRADESH

1. INTRODUCTION

Central Ground Water Board has taken up the task of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity in the state. In order to arrive at proper parametric indices of evaluation and judicious development of ground water resources, the Board is monitoring a National Network of Hydrograph Stations (NHS) on long term basis since 1969 through a network of wells (Dug wells and Piezometers) for studying its long term behaviour due to influence of rainfall and ground water development. A historical database on the ground water levels and water quality has been developed over a period of time since the year 1969.

The monitoring mainly comprises measurement of water levels and temperature, four times in a year viz., in the months of May (pre-monsoon), August (mid-monsoon), November (post-monsoon) and January and collection of water samples during May every year, for chemical analysis. As on 31-03-2017, there were 855 operational Ground Water Monitoring Wells (GWMS (742 dug wells and 113 piezometers). During the year (2017-18), 29 Ground water monitoring wells (27 Dug wells and 2 Piezometers) were abandoned and 39 new ground water monitoring wells (3 DW and 36 PZ) were established. As on March 2018, the status of monitoring stations is 875 wells, out of which, 727 are Dug wells and 148 Piezometers.

The dug wells tapping unconfined aquifers are mostly confined to village limits, which are used for domestic purpose. Some of these are community wells and the rest belong to private individuals. The piezometers tapping unconfined and confined aquifers constructed under various projects and exploration programmes by the department are monitored manually four times a year. The location of network of monitoring wells is presented in the **Fig.1.1.**

1.1 Location and Extent

Andhra Pradesh State is the **7th largest state** in India covering geographical area of 1, 63,000 Km^2. It lies between NL 12° 37' and 19° 09' and EL 76° 45 ' and 84° 47'. The State is bordered on the east by Bay of Bengal (~970 km), south by

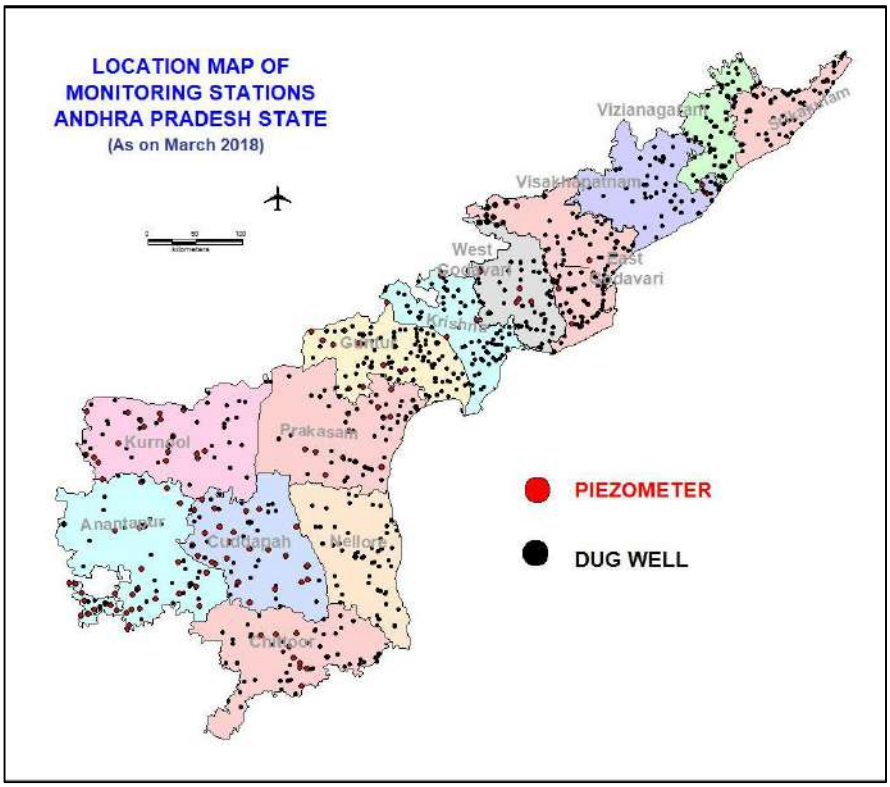


Fig.1.1: Location of GWMS in Andhra Pradesh State (as on 31st March, 2018).

Tamilnadu and Karnataka, west by Karnataka and Telangana and north by Telangana, Chattisgarh and Orissa states (**DES, Govt of AP, 2015**).

Administratively, the State is divided into 13 districts (Srikakulam, Vizianagar, Vishakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasham, SPS Nellore, YSR Cuddapah, Kurnooll, Ananthapuramu and Chittoor) and governed by 670 revenue mandals (mandals) with 17398 revenue villages. Total population of the state (2011 census) is ~4.96 Crores (with male-female ratio of 997) of which 90 % lives in rural area and 10% in urban area. The density of population varies from 188 persons/km^2 in YSR Cuddapaha to 518 persons/km^2 in Krishna district (average density: 304 persons/km^2). The overall growth in total population

during decade is ~9.2 % (2001 to 2011 census) (**DES, Govt of Andhra Pradesh, 2015**). The present ground water year book (2017–18) depicts the ground water **l**evel scenario in the State and describes the behaviour of water levels during the period.The piezometric data of Ground Water Department , Govt of A.P. is also integrated in order to have realistic water level scenario.

2. PHYSIOGRAPHY, DRAINAGE AND SOIL

2.1 Physiography

Physiographically, Andhra Pradesh State can be divided into three distinct zones, viz., Coastal plains, Eastern Ghats and Western pediplains. The first two zones stretch from north-east to south-west in a narrow strip while 3rd zone occupy rest of the area. The elevation ranges from 0 to > 600 m above mean sea level (a msl) (**Fig.2.1**).

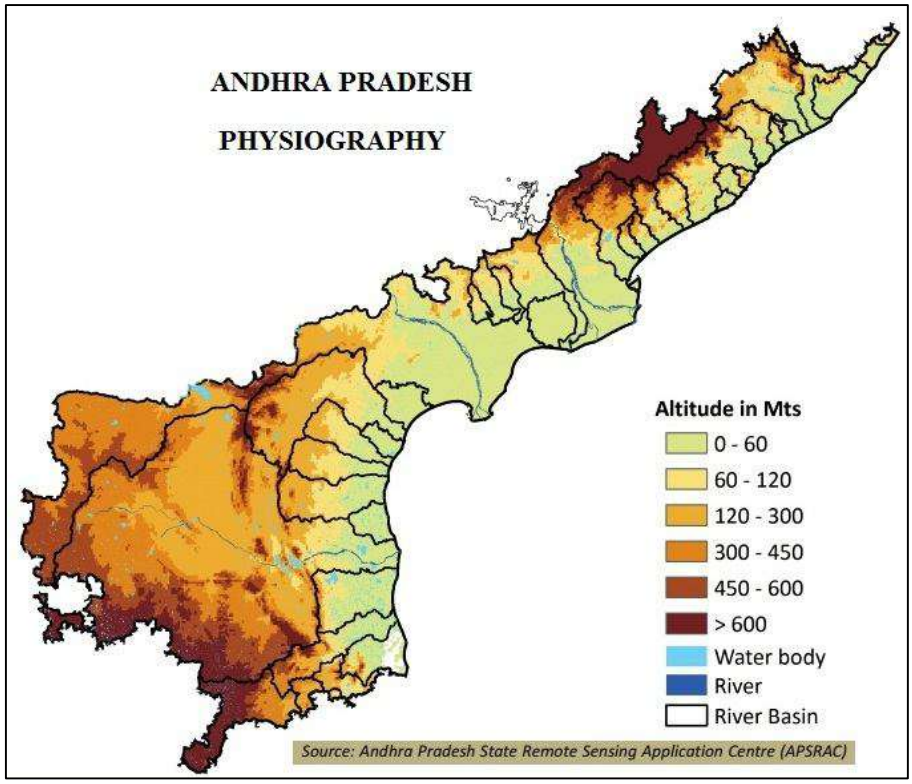


Fig.2.1: Physiography map of Andhra Pradesh (after APRAC-2014).

2.1.1 Coastal Plains

The coastal plains stretch from Kalingapatnam (Srikakulam district) in north to Pulicat (Nellore district) in south along a narrow strip, which broadens in the middle along Godavari-Krishna deltas (up to 80 km^2). The altitude of coastal plains ranges from sea level at the coast to 150-200 m amsl on the west. The area has rich agricultural land owing to two deltas.

2.1.2 Eastern Ghats

The Eastern Ghats follow the Coastal Plains stretching closely from one end to other end except in area between the Godavari and Krishna rivers. The hill ranges trend in NE - SW direction in the north and in N-S direction in the south and attain an elevation of 600 to 1200 m amsl. The Nallamala, Erramala, Seshachalam, Velikonda and Palakonda hills falling in Rayalaseema region, cover southern section of Ghats**.**

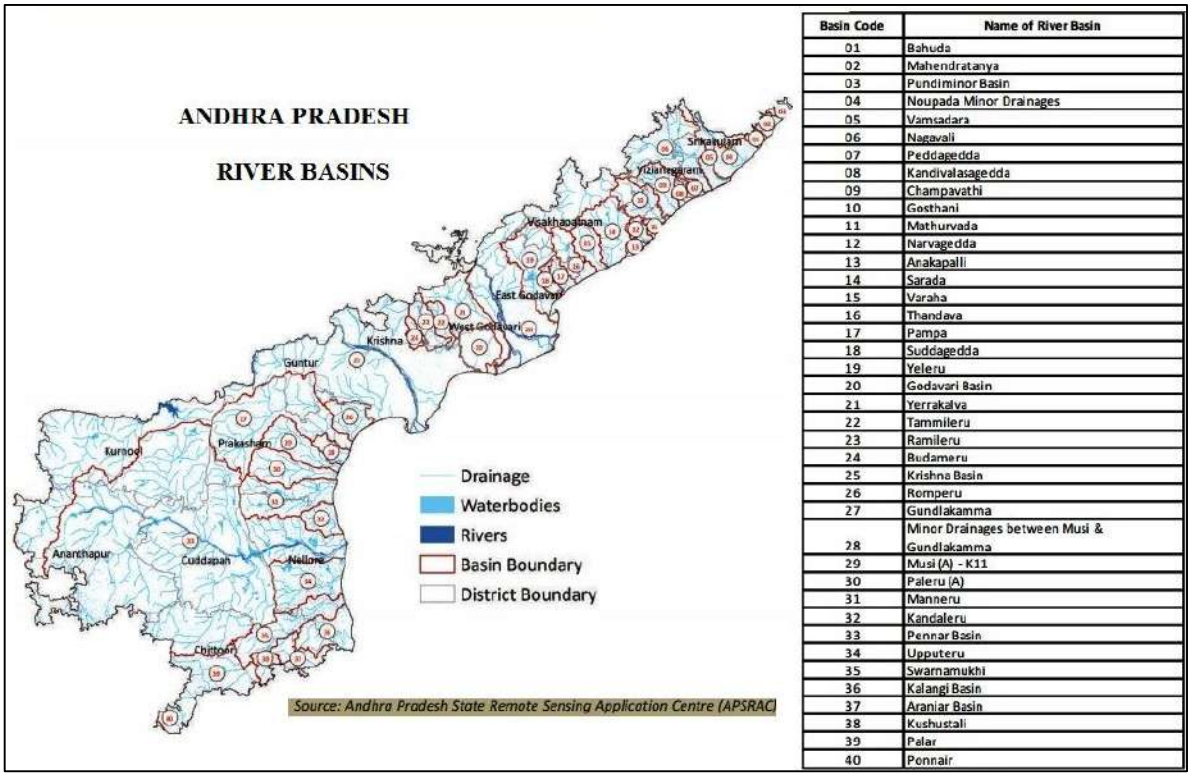
2.1.3 Western Pedeplains

A major part of State covering parts of Rayalaseema region (Kurnool and Anantapur districts), fall in this category. The pedeplains show rolling topography with flat to undulating tracts. This plateau in the interior of the State extends largely between elevation of 150 to 600 m amsl except at places where the elevation ranges from 600 to 900 m amsl.

2.2 Drainage

Godavari and Krishna rivers and their tributaries drain the northern and central part and Pennar river drains in southern part of state before joining Bay of Bengal (**Fig. 2.2**). There are 3 major basins and 11 medium river basins in the state. The major river basins are Godavari, Krishna and Pennar and medium basins are Vamsadhara, Nagavali, Sarada, Yeleru, Gundlakamma, Paleru (A), Manneru, Uppateru, Swarnamukhi, Palar and minor drainages between Musi and Gundlakamma river. The drainage pattern is generally dendritic with wide valleys in western peneplain. The drainage in Eastern Ghat is coarse and dendritic with steep and narrow valleys. Youthful streams and valleys mark the eastern coastal tract intersected by innumerable feeder and distributory canal system. The mature river courses of Godavari, Krishna and Pennar meanders through the vast areas and are covered by delats as well as coastal plains. The deltas of rivers are very extensive and charecterised by considerable thichness of alluvial material.

Most of the smaller streams feed innumerable tanks. River Penna flows across the southern part of the state with its tributaries Chitravati, Papaghni, Kundu, Sagileru and Cheyyeru and drains major part of Rayalaseema region and Nellore district of coastal region. The drainage basins are charecterised by undulating topography comprising a series of ridges and valleys intersperse by hill ranges. Vamsadhara and Nagavalli rivers with their distributaries drain the northeastern part of the state in Srikakulam district. Visakhapatnam district is mostly drained by local rivulets like Sarada. River Yeleru drains most of the East Godavari district while Yerrakalava, Tammileru drain West Godavari district. Nellore district is drained by Pennar, Swarnamukhi and Araniar rivers.



Basin Code	Name of River Basin
01	Bahuda
02	Mahendratanya
03	Pundiminor Basin
04	Noupada Minor Drainages
05	Vamsadara
06	Nagavali
07	Peddagedda
08	Kandivalasagedda
09	Champavathi
10	Gosthani
11	Mathurvada
12	Narvagedda
13	Anakapalli
14	Sarada
15	Varaha
16	Thandava
17	Pampa
18	Suddagedda
19	Yeleru
20	Godavari Basin
21	Yerrakalva
22	Tammileru
23	Ramileru
24	Budameru
25	Krishna Basin
26	Romperu
27	Gundlakamma
28	Minor Drainages between Musi & Gundlakamma
29	Musi (A) - K11
30	Paleru (A)
31	Manneru
32	Kandaleru
33	Pennar Basin
34	Upputeru
35	Swarnamukhi
36	Kalangi Basin
37	Araniar Basin
38	Kushustali
39	Palar
40	Ponnair

Fig.2.2: Drainage and River sub-basin map of Andhra Pradesh State.
(After APRAC-2014).

2.3 Soils

The State has a wide variety of soils viz., Red soil, Laterite, Black Cotton soil, Deltaic Alluvium soil, Coastal soil and Saline soil. Red clayey soil occur predominantly in Srikakulam, Visakhapatnam, East Godavari and West Godavari districts in coastal region. Black cotton soil commonly occurs in Krishna and Guntur districts. Red earths with loamy sub-soil and red sandy loamy soil occur in Prakasam and Nellore districts and Laterite soils in Nellore and Prakasam districts. Black cotton soil occurs in part of Kadapa, Kurnool and Anantapur district and red loamy soils occur in parts of Chittoor and Kadapa districts. Red earths are predominant in Anantapur district. Soil map of AP is given in **Fig. 2.3.**

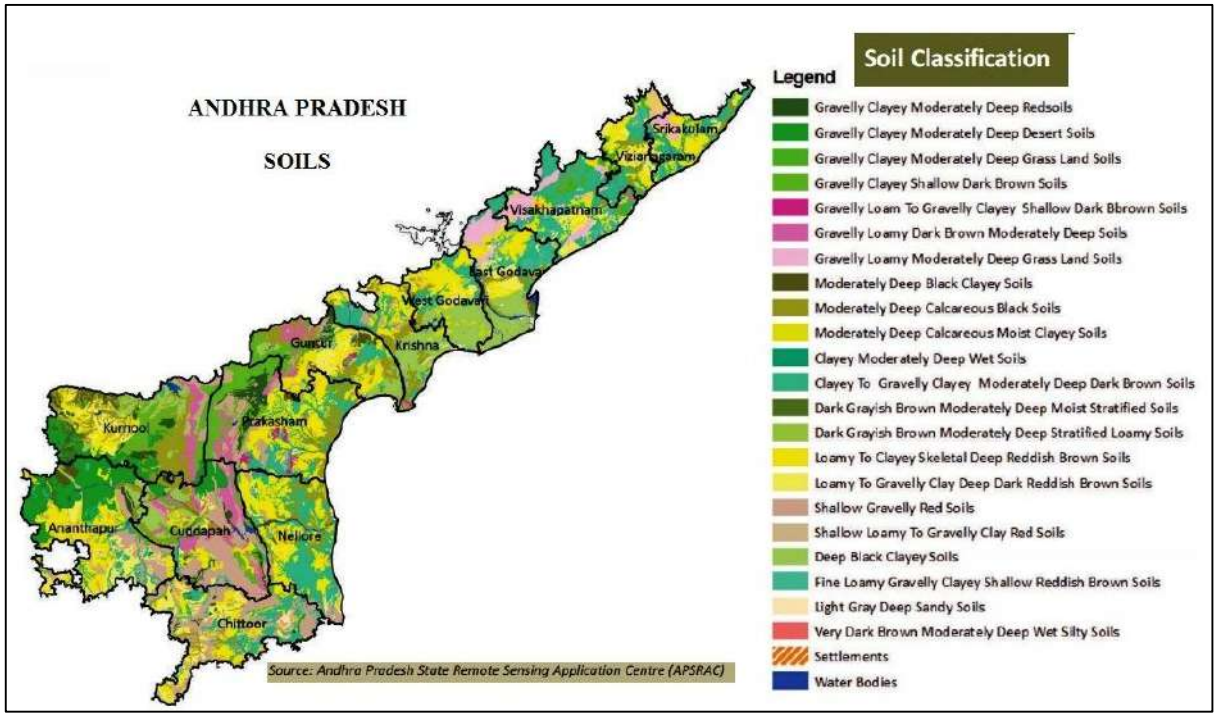


Fig.2.3: Soil Map of Andhra Pradesh (after APSRAC-2014).

3. HYDROMETEOROLOGY

3.1 Climate

The climate of the state is tropical in nature and is influenced by the topographical variations and maritime influence. The Deccan Plateau has more of a temperate climate than the coastal belt. The Eastern Ghats in Vishakhapatnam and its neighborhood play a significant role, which acts as a barrier to easterly winds in association with depression from Bay of Bengal during the southwestern monsoon. The Agro-climatic classification (Agricultural Department) of the state is given in the **Table-3.1**.

Region	Classification
Rayalaseema	Scarce rainfall zone
Plateau	Southern zone
	Krishna – Godavari Zone
Coastal	North Coastal zone
Andhra Pradesh	South Coastal zone
	High Altitude
	Tribal Zone
	Scarce Rainfall Zone

3.2 Rainfall Analysis - 2017

District-wise monthly, seasonal, annual and normal rainfall and departure from normal is given in the Table-3.2. The district-wise departure from normal is depicted in **Fig. 3.1**. The salient features of rainfall analysis are as under:

- The normal annual rainfall is 950 mm. Season-wise normal rainfall is 555 mm, 285 mm, 9.8 mm and 96.2mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, 58% of annual rainfall occur in SW monsoon, 30% in north-east and 12% in non-monsoon seasons. Annual normal rainfall ranges from 341 mm in Atmakur mandal, Anantapuramu district to 1623 mm in Munchingipattu mandal, Visakhapatnam district **(Fig 3.2).**

- The mean annual rainfall during 2017 is 898 mm. Season-wise rainfall is 652 mm, 203 mm, 0 mm and 43 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 73 of annual rainfall in SW monsoon, 23% in north-east and 4% in non-monsoon seasons. The annual (2017) rainfall ranges from 589 mm in Anantapuramu district (more from normal by 3%) to 1274 mm (more by 9%) in Srikakulam district. Annual rainfall was deficit in Prakasam district. In all other districts is was normal. Monthly mean rainfall ranges from Nil in January, February and March to 223 mm in August.

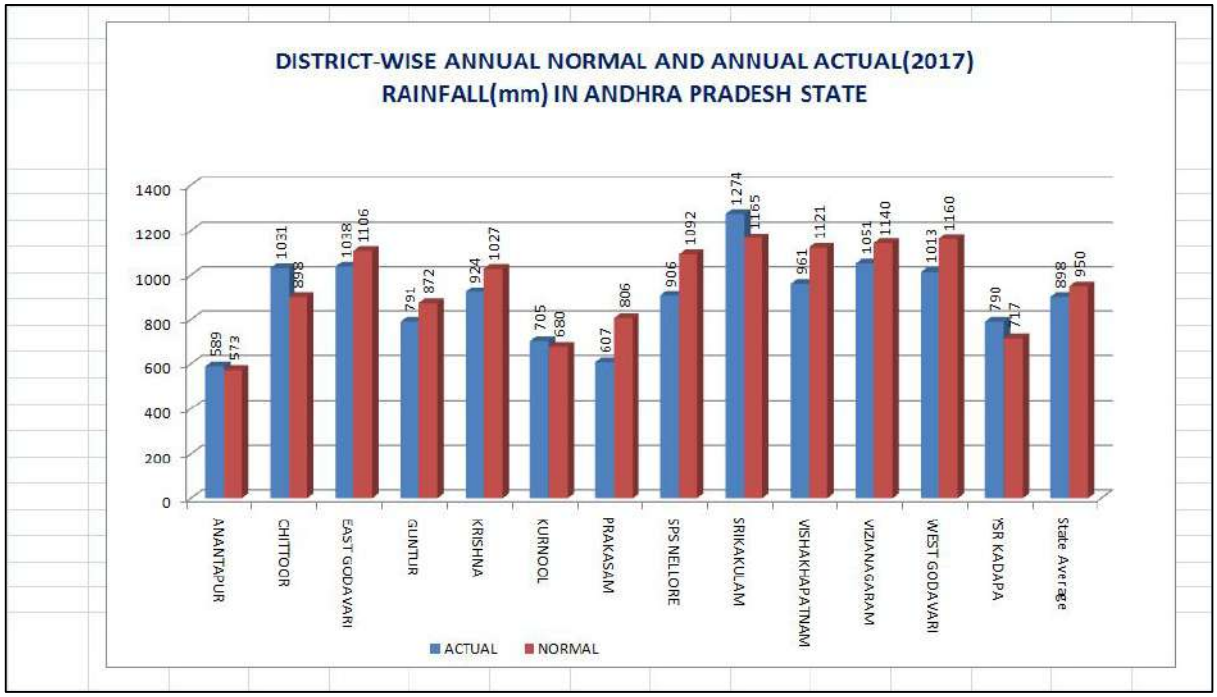


Fig.3.1: District-wise Annual Normal and Actual (2017) rainfall.

The rainfall received during the period Jan, 2017 to Dec, 2017 is compiled and analysed for correlating with water levels monitored during the period May, 2017, Aug, 2017, Nov,2017 and Jan, 2018. The data is presented in **Table-3.2 to 3.5** and depicted in the **Fig. 3.3 to 3.10.**

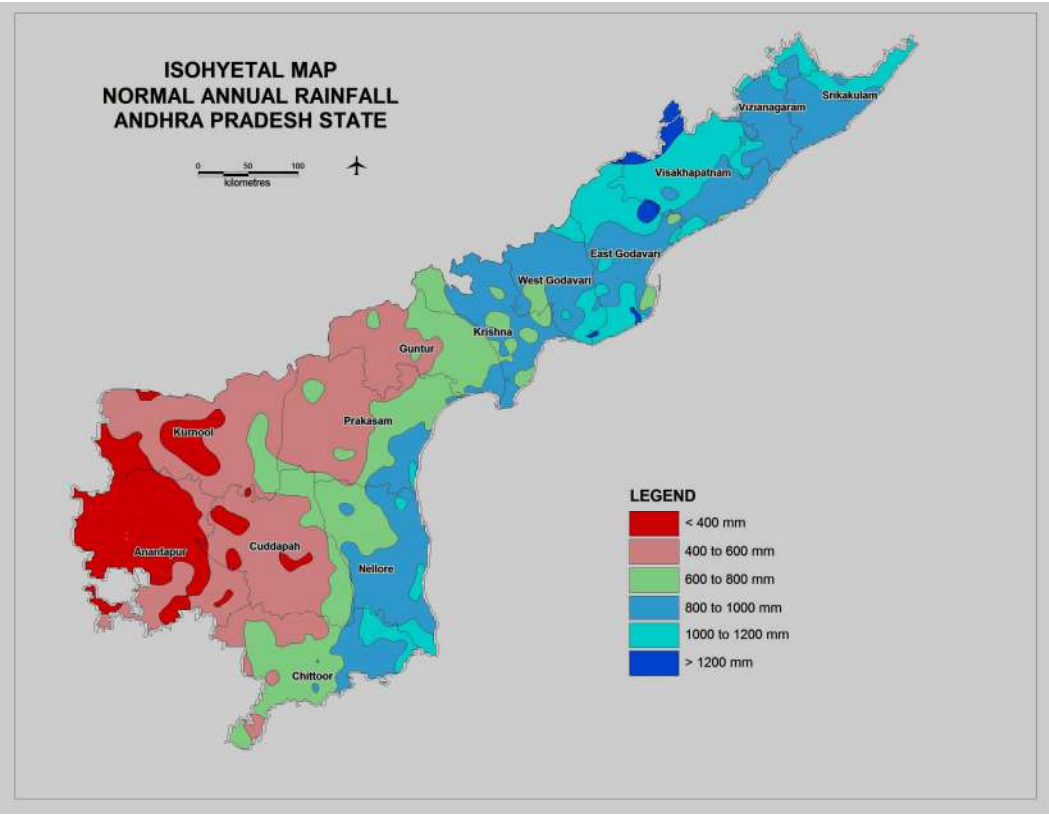


Fig.3.2: Isohytel map of Andhra Pradesh State (Normal annual rainfall in mm).

Table-3.1: Monthly Normal and Actual (2017) rainfall (mm) in Andhra Pradesh State.

		JAN		FEB		MAR		APR		MAY		JUNE		JULY	
S No	**DISTRICT**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**
1	ANANTAPUR	0	3	0	3.3	0	6.1	44.2	18.9	9.2	56.7	60.8	55.2	31.3	64.3
2	CHITTOOR	0	7.7	0	7.6	0	10.1	55.4	25.6	9	67.2	92.3	66.8	85	100.1
3	EAST GODAVARI	0	6	0	10.1	0	11.3	17.5	22.8	7	75.3	248.8	131.9	247.2	206.4
4	GUNTUR	0	5.5	0	7.7	0	7.7	40.5	15	2.1	58.4	169.1	90.2	139.9	147.3
5	KRISHNA	0	4.6	0	6.3	0	8.7	25.1	16.9	0.4	46.8	176.6	120.9	216.2	216.6
6	KURNOOL	0	1.2	0	1.9	0	5.7	24.8	18.3	8.9	51.7	109.2	80.5	57.8	115.8
7	PRAKASAM	0	7.9	0	8.8	0	10.5	31.1	14.9	14.9	52.3	90	64.3	72	99.3
8	SPS NELLORE	0	15.7	0	11.6	0	6	21.3	15.2	3.6	51.4	91.2	53.4	73	91.2
9	SRIKAKULAM	0	7.9	0	18.1	0	17.2	33.5	26.3	16.6	63.9	138.5	145	278.8	190.2
10	VISHAKHAPATNAM	0	8.8	0	10.8	0	17.6	42	44.7	19.3	96.6	203.6	132.6	126.5	178.2
11	VIZIANAGARAM	0	8.7	0	14.4	0	17.7	53.8	32.3	5.1	90.7	110.1	140.7	144.1	181.5
12	WEST GODAVARI	0	6.1	0	10.7	0	8.7	24.4	19	6	55.8	182.6	135.8	258.8	240.2
13	YSR KADAPA	0	1.9	0	2.4	0	4.7	36.8	17.3	8.2	47.6	97	69.8	39.4	101.1
	State Average	**0.0**	**6.5**	**0.0**	**8.7**	**0.0**	**10.2**	**34.6**	**22.1**	**8.5**	**62.6**	**136.1**	**99.0**	**136.2**	**148.6**

		AUG		SEP		OCT		NOV		DEC		ANNUAL		
S No	**DISTRICT**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**ACT**	**NOR**	**DEP(%)**
1	ANANTAPUR	96.3	74.5	129	128.8	209	115	8	35.3	1	11.6	**589**	573	**3%**
2	CHITTOOR	230	110	140	140	289	167.2	100	137.3	30	58.4	**1031**	898	**15%**
3	EAST GODAVARI	208.3	188	177	177.2	128	199	4	69.8	0	7.8	**1038**	1106	**-6%**
4	GUNTUR	187	155	150	150.1	94	143.9	8	75.8	0	14.5	**791**	872	**-9%**
5	KRISHNA	207.4	194	170	169.7	111	164.2	16	66.1	1	12.1	**924**	1027	**-10%**
6	KURNOOL	188.3	124	140	139.6	175	105.6	1	28.4	0	6.6	**705**	680	**4%**
7	PRAKASAM	176	95.9	123	123	89	181.9	11	115	0	32.1	**607**	806	**-25%**
8	SPS NELLORE	197	95	113	112.8	177	248.2	222	283.9	8	107.2	**906**	1092	**-17%**
9	SRIKAKULAM	354.1	202	208	208.1	137	211.4	106	69.8	1	4.9	**1274**	1165	**9%**
10	VISHAKHAPATNAM	252	178	185	185.4	127	204.3	6	59.2	0	4.3	**961**	1121	**-14%**
11	VIZIANAGARAM	336	195	209	209.1	158	188.1	35	56.3	0	6.1	**1051**	1140	**-8%**
12	WEST GODAVARI	236	228	180	180.1	121	197.8	4	66.7	0	11.7	**1013**	1160	**-13%**
13	YSR KADAPA	225	109	125	124.6	222	137.3	36	77.2	1	24.4	**790**	717	**10%**
	State Average	**222.6**	**150.0**	**157.6**	**157.6**	**156.7**	**174.1**	**42.8**	**87.8**	**3.2**	**23.2**	**898**	**950**	**-5%**

3.2.1 May, 2017

3.2.1.1 Rainfall Analysis (June, 2016 - May, 2017 from June, 2015 to May, 2016 rainfall)

The rainfall data collected from India Meteorological Department and compiled from weekly weather reports has been used to analyze the rainfall for the period June, 2015 to May, 2017. **Table 3.2** gives the district-wise rainfall data for the period June, 2015 –May, 2016, June, 2016 – May, 2017 and normals of Jun – May and the departure of June, 2016-May, 2017 rainfall with other periods. The departure values are used to prepare the graphs and presented in **Fig 3.3 and Fig 3.4.**

Table-3.2: District-wise rainfall (June'16-May'17) and its departure from normal and June'15-May'16

S No	District	Rainfall (June'16-May'17)	Rainfall (June'15-May'16)	Normal Rainfall (June-May)	Departure(%) of col(4) from col(3)	Departure (%) of col(3) from col(5)	Remark
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	343	662	573	-48.2%	-40.1%	Deficit
2	Chittor	616	1353	898	-54.5%	-31.4%	Deficit
3	Cuddapah	566	965	717	-41.3%	-21.0%	Deficit
4	East Godavari	994	1158	1106	-14.2%	-10.1%	Normal
5	Guntur	895	789	872	13.4%	2.7%	Normal
6	Krishna	918	965	1027	-4.9%	-10.6%	Normal
7	Kurnool	564	479	680	17.7%	-17.0%	Normal
8	Nellore	489	1426	1092	-65.7%	-55.2%	Deficit
9	Prakasam	531	653	806	-18.7%	-34.1%	Deficit
10	Srikakulam	939	1095	1165	-14.2%	-19.4%	Deficit
11	Vishakhapatnam	986	1166	1121	-15.4%	-12.0%	Normal
12	Vizianagaram	1032	1168	1140	-11.6%	-9.5%	Normal
13	West Godavari	1074	1117	1160	-3.8%	-7.4%	Normal
	STATE MEAN	**765**	**1000**	**950**	**-23.5%**	**-19.5%**	**Deficit**

Source: India Meteorological Department, GOI

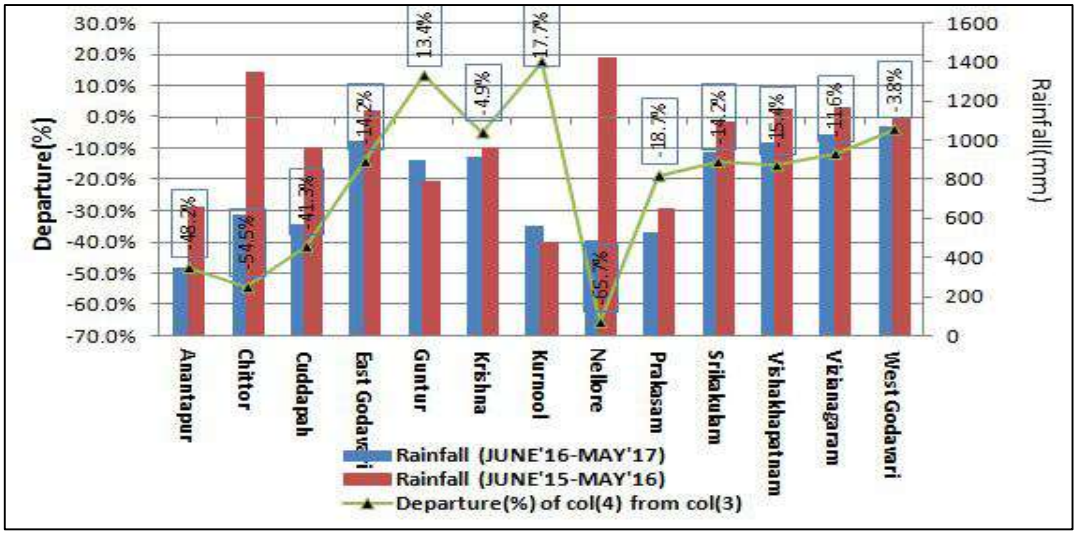


Fig.3.3: Rainfall Departure (June,2016- May,2017 from June,2015-May,2016)

Figure 3.3 gives departure of June, 2016- May, 2017 vs June, 2015 to May, 2016. It is prepared to correlate with water level fluctuation map of May 2017 vs May 2016. **Table 3.2** indicates that state has received 765 mm of rainfall during the period June, 2016 – May, 2017, which is 23.5 % less than the rainfall received during June, 2015 to May, 2016. The departure in percentage ranges from -65.7 % in SPS Nellore district to 17.7 % in Kurnool district.

3.2.1.2 Departure of rainfall during June, 2016-May, 2017 from normal rainfall of same period

Figure 3.4 gives departure of Jun'16- May'17 rainfall with normal of the same period. It is prepared to correlate with depth to water level map of May 2017. During the period Jun'16- May'17, the state has received 19.5 % less rainfall than normal, which is 950 mm. It ranges from –55.2% in SPS Nellore district to 2.7 % in Guntur district. Anantapur, Chittoor, Kadapa, SPS Nellore, Srikakulam and Prakasam districts received deficit rainfall and other districts have received normal rainfall.

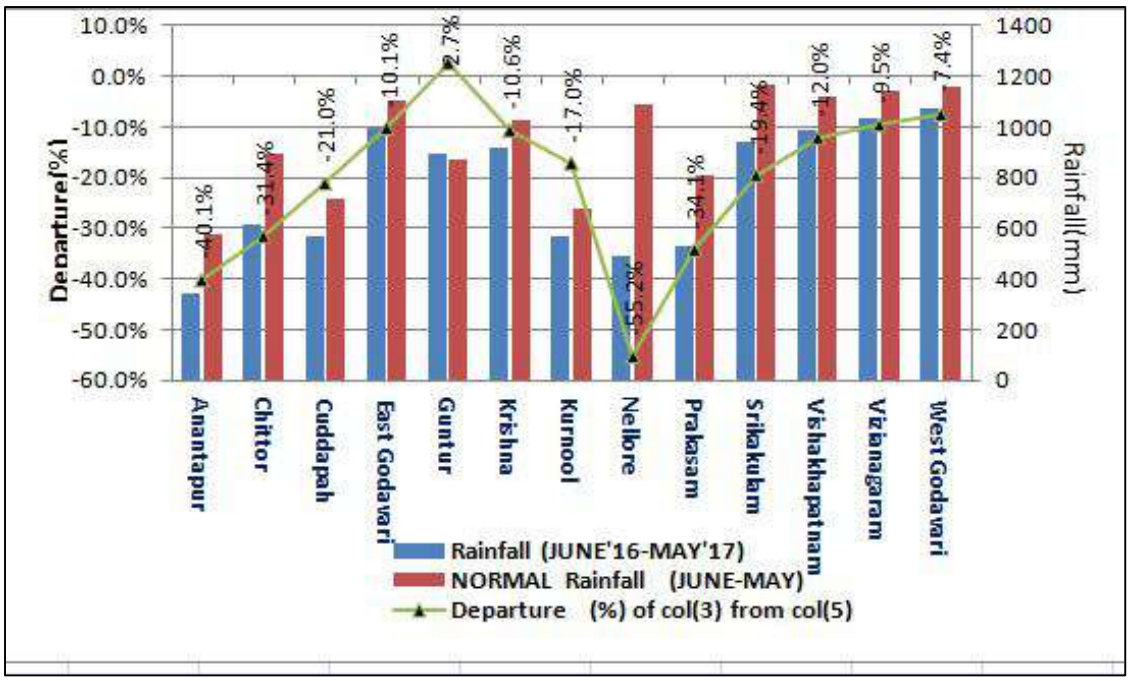


Fig.3.4: Rainfall Departure - Jun'15- May'16 from Normal of same Period.

3.2.2 August, 2017

The district wise rainfall for the period June,2017 -August,2017 from June,2016 – August, 2016 is given in **Table-3.3** and different thematic maps are presented in **Fig.3.5, and 3.6**.

Table-3.3: District-wise rainfall (June'17-Aug'17) and its departure from normal and June'16-Aug'16

S NO	DISTRICT	Rainfall (JUNE'17-AUG'17)	Rainfall (JUNE'16-AUG'16	NORMAL Rainfall (JUNE-AUG)	Dep(%) of June-Aug(2017) from June-Aug(2016)	Departure (%) of June-Aug(2017) from Normal(June-Aug)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Anantapur	217	188	194	15.4%	11.9%
2	Chittor	313	407	277	-23.1%	13.0%
3	Cuddapah	330	361	280	-8.6%	17.9%
4	East Godavari	630	704	527	-10.5%	19.5%
5	Guntur	482	496	393	-2.8%	22.6%
6	Krishna	596	600	532	-0.7%	12.0%
7	Kurnool	354	355	321	-0.3%	10.3%
8	Nellore	182	361	240	-49.6%	-24.2%
9	Prakasam	252	338	260	-25.4%	-3.1%
10	Srikakulam	453	771	538	-41.2%	-15.8%
11	Vishakhapatnam	537	582	489	-7.7%	9.8%
12	Vizianagaram	531	590	517	-10.0%	2.7%
13	West Godavari	668	677	604	-1.3%	10.6%
	STATE MEAN	**427**	**495**	**398**	**-13.8%**	**7.2%**

Source: India Meteorological Department, GOI

3.2.2.1 Departure of rainfall during June, 2017 to August, 2017 from June, 2016-August, 2016

This map gives departure of rainfall from June 16 to Aug 16 rainfall. It is prepared to correlate with water level fluctuation map of Aug 2017 from Aug 2016. **Table 3.3** indicates that state has received 427 mm of rainfall during the period Jun'17 to Aug'17, which is 13.8 % less than the rainfall received during the same period last year. The state received about 495 mm of rainfall during the same period last year. The departure in percentage ranges from -49.6% in SPS Nellore district to 15.4% in Anantapur district.

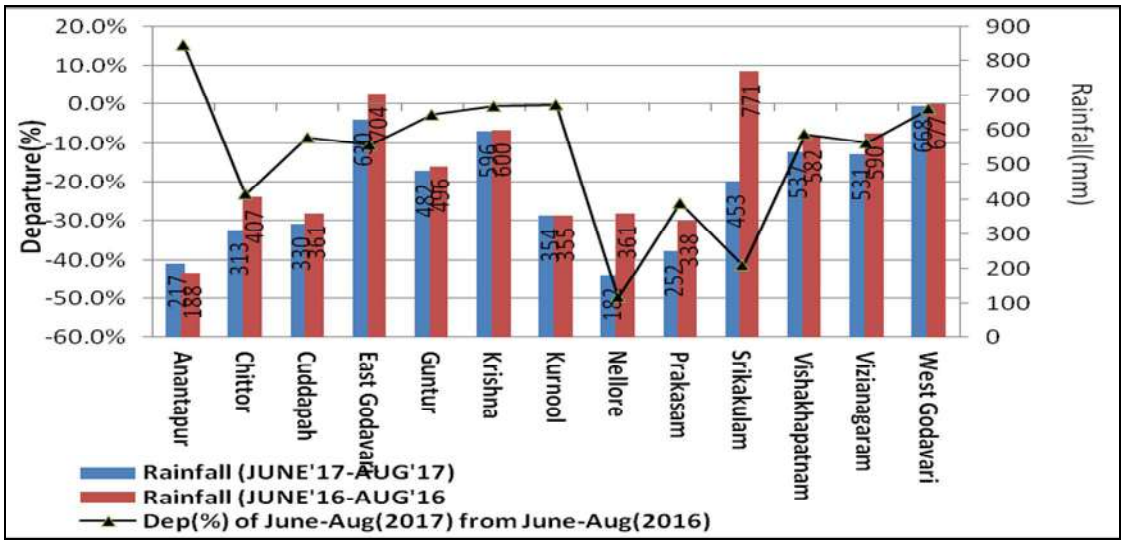


Fig.3.5: Rainfall Departure (June,2017-Aug,2017 from June, 2016-Aug,2016).

3.2.2.2 Departure of rainfall during June, 2017 to August, 2017 from normal rainfall

This map gives departure of June 2017 to Aug 2017 rainfall with normal rainfall of the same period. It is prepared to correlate with depth to water level map of Aug 2017. During the period June 2017 to Aug 2017, the state has received 7.2 % more rainfall (427 mm) than normal rainfall(398 mm) . It ranges from -24.2% in SPS Nellore to 22.6% in Guntur district. The deficit rainfall is observed in SPS Nellore district.

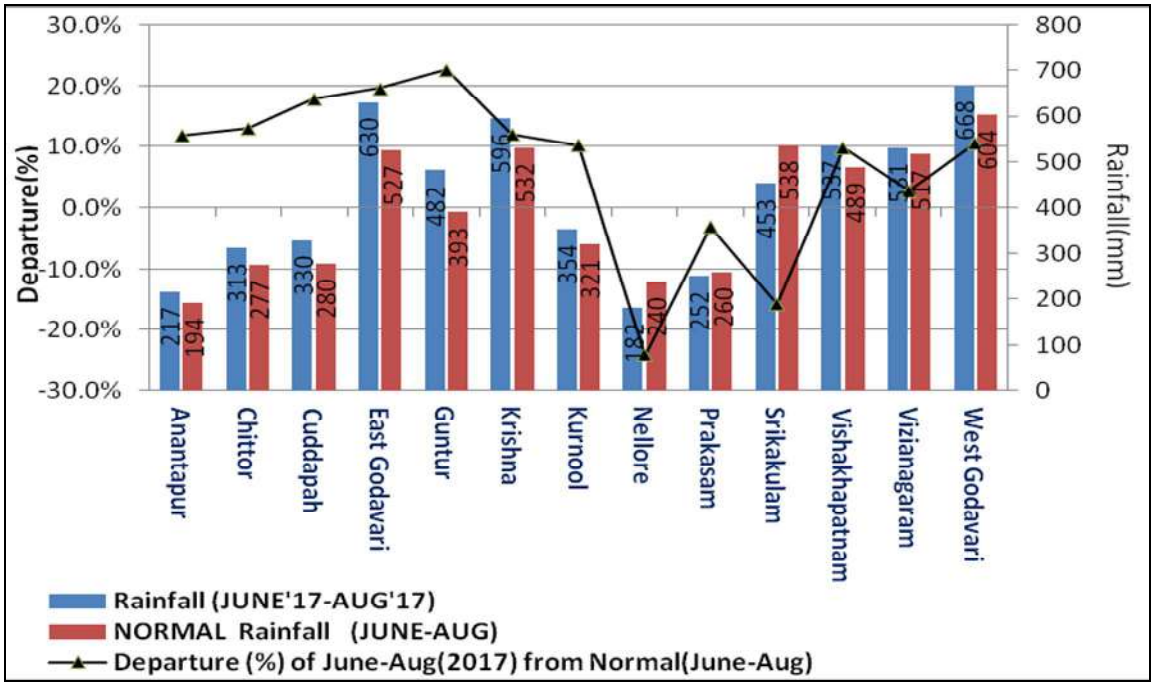


Fig.3.6: Rainfall Departure (June,2017 –Aug,2017 from Normal of the same Period).

3.2.3 November, 2017

The district wise rainfall for the period June, 2017 – October, 2017 from June,2016 – October, 2016 is given in **Table-3.4** and different thematic maps are presented in **Fig.3.7, and 3.8**.

Table-3.4: District-wise rainfall (June'17-Oct'17) and its departure from normal and June'16-Oct'16

S NO	DISTRICT	Rainfall from June'17 to Oct'17	Rainfall from June'16 to Oct'16	Normal from June to Oct	Dep(%) of Rainfall (June'17-Oct'17 from June'16-Oct'16)	Dep(%) of Rainfall (June'17-Oct'17 from Normal)	REMARK
1	Anantapur	526	267.2	438	49.2%	20.1%	Normal
2	Chittor	836	392.4	584	53.1%	43.1%	Excess
3	Cuddapah	708	452.3	541	36.1%	30.8%	Excess
4	East Godavari	1009	955.3	903	5.3%	11.8%	Normal
5	Guntur	740	843.1	687	-13.9%	7.7%	Normal
6	Krishna	881	872.9	866	0.9%	1.8%	Normal
7	Kurnool	670	526	566	21.5%	18.4%	Normal
8	Nellore	651	272.5	601	58.1%	8.4%	Normal
9	Prakasam	550	413.4	564	24.8%	-2.6%	Normal
10	Srikakulam	1116	850.9	957	23.8%	16.6%	Normal
11	Vishakhapatnam	894	916.3	879	-2.5%	1.7%	Normal
12	Vizianagaram	957	970.3	914	-1.4%	4.7%	Normal
13	West Godavari	978	1030.3	982	-5.3%	-0.4%	Normal
	STATE MEAN	**809**	**674**	**729**	**16.7%**	**10.9%**	**Normal**
Source: India Meteorological Department, GOI							

3.2.3.1 Departure of rainfall (June,2017 to October,2017 from June,2016 to Oct, 2016)

It is prepared to correlate with water level fluctuation map of Nov 2017 from Nov 2016. **Table 3.7** indicates that state has received 809 mm of rainfall during the period June 2017 to Oct 2017, which is 16.7 % more than the rainfall received during the same period last year. The departure in percentage ranges from -13.9% in Guntur district to 58.1% in SPS Nellore district. The district-wise rainfall and its departure is given in Fig 2.

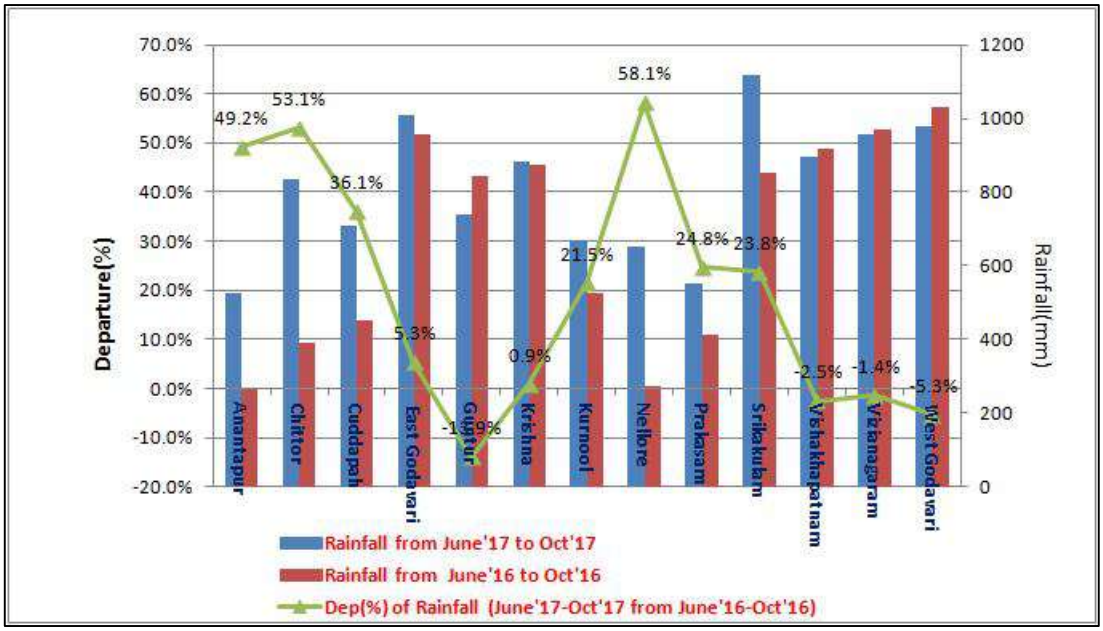


Fig.3.7: Rainfall Departure (June, 2017-Oct, 2017 from June, 2016-Oct, 2016).

3.2.3.2 Departure of rainfall (June 2017 to October-2017 from normal rainfall (June-Oct))

It is prepared to correlate with depth to water level map of Nov 2017. During the period June 2017 to Oct 2017, the state has received 10.9 % more rainfall than normal rainfall. It ranges from -2.6% in Prakasam district to 43.1% in Chittoor district. The state has received normal to excess rainfall during this period, excess rainfall in Chittoor and Cuddapah and normal in rest of the districts. The district-wise rainfall and its departure is given in **Fig 3.8.**

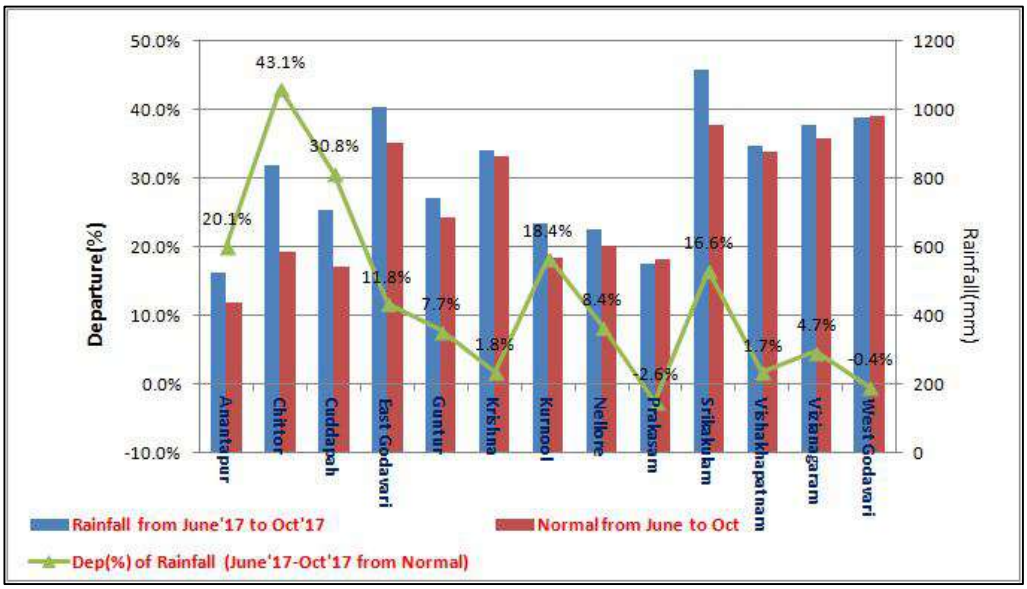


Fig.3.8: Rainfall Departure (June, 2017 - Oct, 2017 from Normals of same Period).

3.2.4 January, 2018

The district wise rainfall for the period June, 2017 to Decemeber, 2017 and normals of same period is given in **Table-3.5** and different thematic maps are presented in **Fig.3.9 and 3.10**.

Table-3.5: District-wise rainfall (June, 17-Dec , 17) and its departure from normal and Jun'16-Dec'16.

S NO	DISTRICT	Rainfall (JUNE'17 - DEC'17)	Rainfall (JUNE'16 - DEC'16)	NORMAL Rainfall (JUNE-DEC)	Departure (%) FROM JUNE'16-DEC'16	Departure from NORMAL	REMARK
1	Anantapur	535	289	485	84.9%	10.4%	Normal
2	Chittor	966	552	780	75.2%	23.8%	Excess
3	East Godavari	1013	970	981	4.5%	3.3%	Normal
4	Guntur	748	853	777	-12.3%	-3.8%	Normal
5	Krishna	898	892	944	0.7%	-4.9%	Normal
6	Kurnool	671	530	601	26.7%	11.7%	Normal
7	Prakasam	561	485	712	15.6%	-21.2%	Deficit
8	SPS Nellore	881	464	992	90.0%	-11.2%	Normal
9	Srikakulam	1223	889	1032	37.6%	18.5%	Normal
10	Vishakhapatnam	900	925	942	-2.7%	-4.5%	Normal
11	Vizianagaram	992	973	977	2.0%	1.6%	Normal
12	West Godavari	982	1044	1060	-5.9%	-7.4%	Normal
13	YSR Kadapa	745	521	643	42.9%	15.9%	Normal
	STATE MEAN	**855**	**722**	**840**	**18.4%**	**1.7%**	**Normal**
Source: India Meteorological Department, GOI							

3.3.4.1 Departure of rainfall during Jun,2017 to Dec,2017 from Jun,2016 to Dec,2016

The rainfall data for the period June, 2017 to Dec, 2017 compiled and collected from India Meteorological Department has been used to analyze the rainfall data for preparing the graphs. District-wise rainfall data for the period June, 2016 – Dec, 2016, June, 2017 to Dec, 2017 and normal of June-Dec and the departure of Jun, 2017- Dec, 2017 rainfall with the rest of the periods is given **Table 3.5.**

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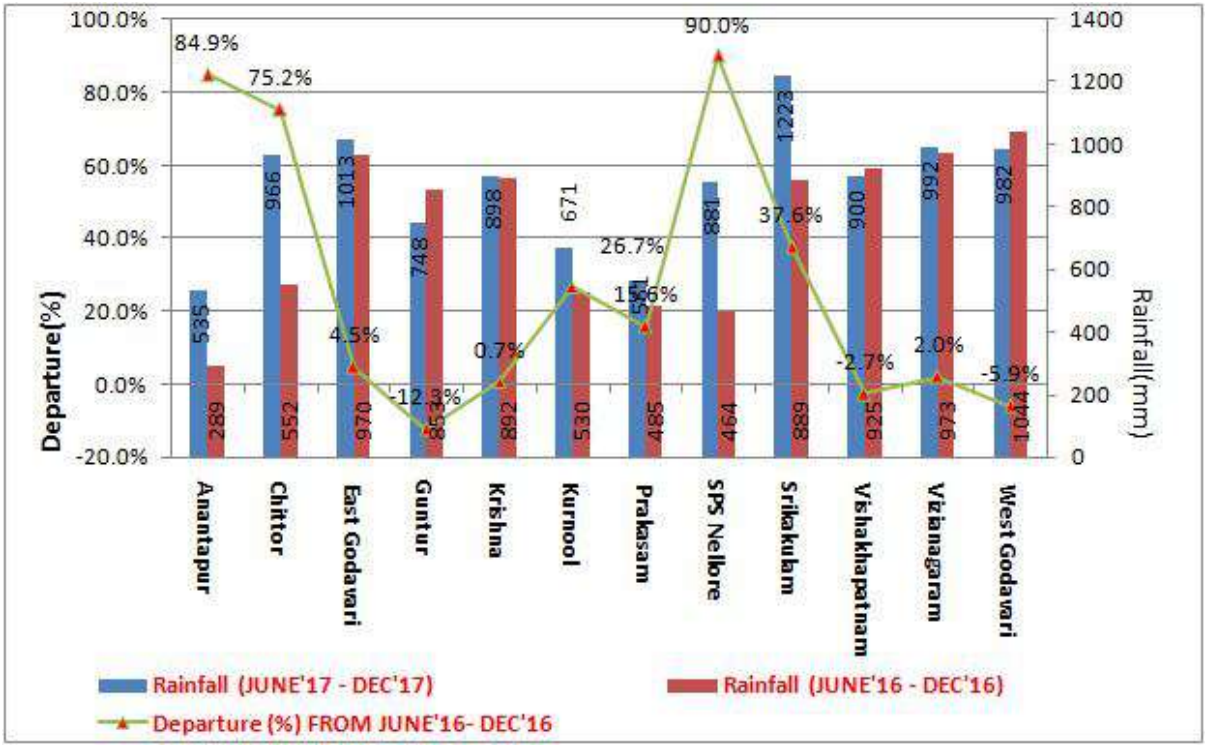

Fig.3.9: Rainfall Departure (June,2017-Dec,2017 from June,2016-Dec,2016).

3.2.4.2 Departure of rainfall during Jun, 2017 –Dec, 2017 from normal rainfall of the same period

It is prepared to correlate with depth to water level map of Jan, 2018. During the period June, 2017 to Dec, 2017 , the state has received 855 mm which is 1.7 % more than the normal rainfall. It ranges from -21.2% in Prakasam district to 23.8% in Chittoor district. The state has received normal to excess rainfall in all the districts during this period except in Prakasam district. . Excess rainfall is recorded in Chittoor district and normal in rest of the districts. The district-wise rainfall and its departure is given in **Fig 3.10.**

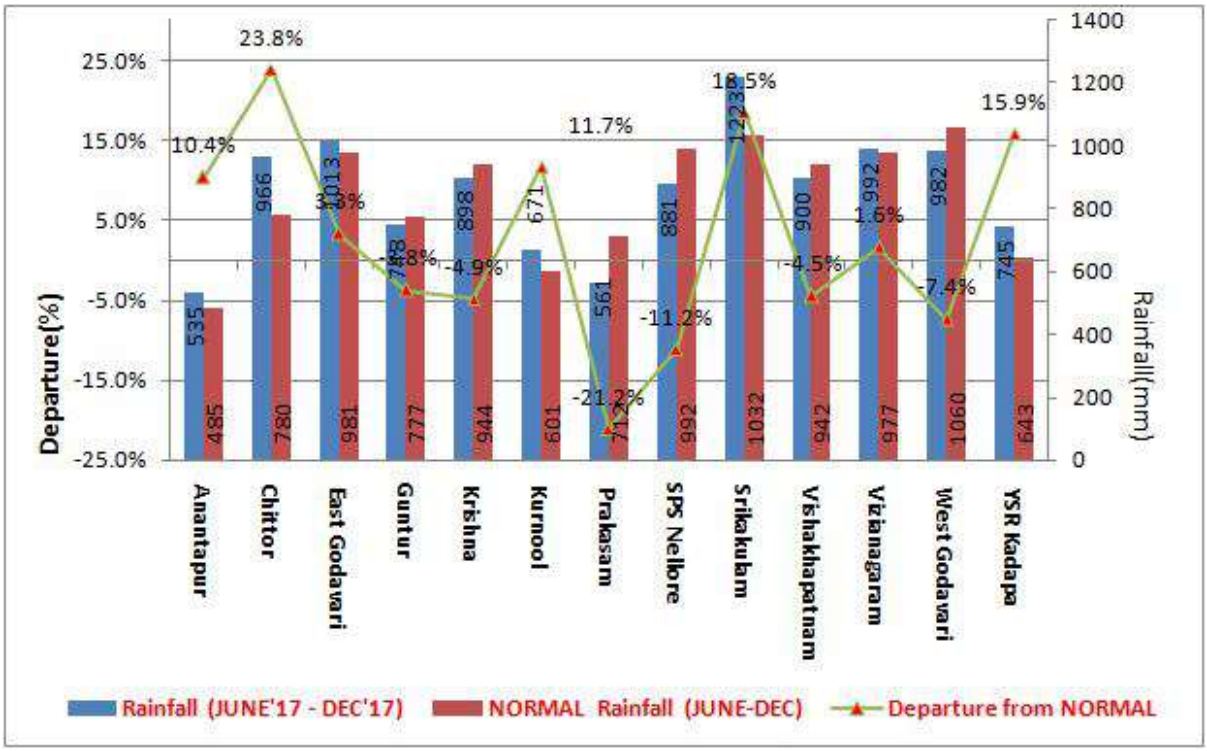

Fig.3.10 Rainfall Departure (Jun,2017- Dec,2017 from Normals of same Period).

4. GEOLOGY

A wide variety of geological formations occur in Andhra Pradesh State, ranging from the oldest Archaean crystalline formations to recent alluvium. The geological set up and hydrogeological map is presented in the **Fig.4.1** and **4.2** respectively. A major part of the area is underlain by gneissic complex with a structural fill of sedimentary formations and basin-fill of meta-sedimentary formations. The gneissic complex is overlain by basaltic lava flows in the northwestern part and is intruded by several younger rocks namely granites, dolerites, pegmatites and quartzite etc.

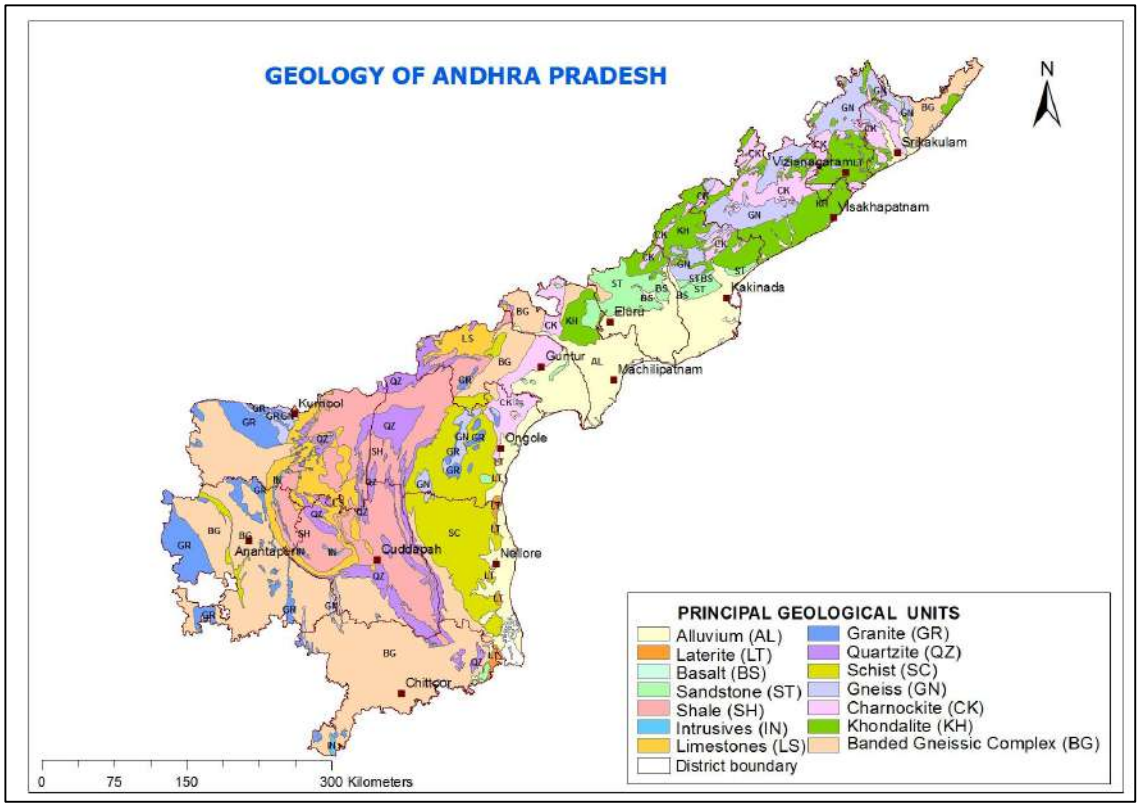

Fig.4.1: Geology of Andhra Pradesh State.

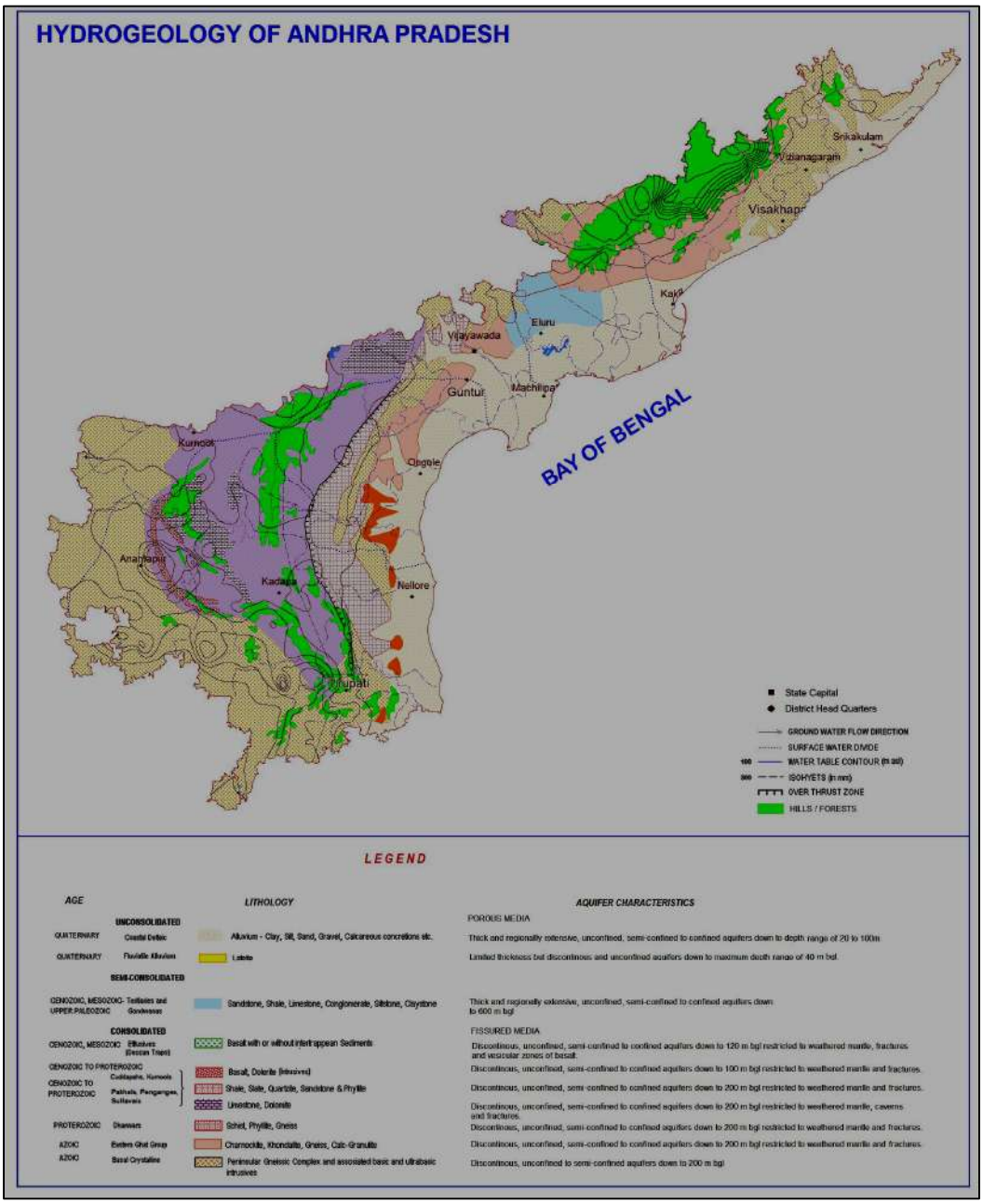

Fig.4.2: Hydrogeology map of Andhra Pradesh State.

4.1 Archaeans and Lower Pre-Cambrians

Peninsular gneisses of Archaean age are dominant rock types in Rayalaseema region of the State. Dharwars, comprising amphibolites, gneisses, schists, and quartzites occur as narrow isolated bands within granites in Chittoor, Anantapur, Kurnool, Kadapa, Nellore and Prakasam districts.The Charnockites and Khondalites occur in an extensive belt in Srikakulam, Vizianagaram, and Visakhapatnam districts and in upland areas of East Godavari

and West Godavari districts. The Charnockite bands also occur as narrow patches adjoining Coastal alluvium in Krishna, Guntur and Prakasam districts.

4.2 Upper Pre-Cambrian to Early Pre-Cambrian

The group includes Cuddapahs, and Kurnools comprising shales, limestones, dolomites, sandstones and conglomerates. The crescent shaped Cuddapah Super Group covering ~42,100 Km^2 occur in parts of Krishna, Kurnool, Prakasam, Guntur, Nellore, Kadapa, Chittoor and Anantapur districts. Kurnools occur in Kundair valley and Palnad tract. Gondwanas also occur as disconnected outcrops along the coast from Tuni in East Godavari district to Satyavedu in Chittoor district.

4.3 Deccan Traps (Basalt) and Associated Rocks

Deccan traps, the horizontally disposed lava flows are confined to Minor outcrops near Rajahmundry on either banks of the river Godavari. The thickness of individual flow varies between few metres to as much as 30 m. Inter-trappean beds comprising limestones, cherts and sandstones occur between trap flows near Rajahmundry. Infra-trappean beds, comprising deposits of limestones and sandstones, underlie the trap flows. These are exposed in an area covering a stretch of 6 km from Pangidi in West Godavari district to Kateru in East Godavari district.

4.4 Tertiary Formations (Miocene-Pliocene)

The formation of this group is locally known as Rajahmundry formation. It constitutes mainly Sandstones occurring from Eluru to Rajahmundry as isolated out crops dipping gently towards the coast. Sandstones of equivalent age occur along the southern coast in Chittoor, Prakasam and Nellore districts. They are highly potential from ground water point of view.

4.5 Quaternary Formations

Alluvium, beach sands, Laterite soils etc. belong to this group. Beds of clay, sand, gravel and boulders stretch along the coast except near Visakhapatnam. This distribution is not only confined to deltas but also extends deep inland in narrow patches along river courses of Godavari, Krishna, Pennar and Vamsadhara. The alluvial deposits attain a thickness of more than 600 m in East and West Godavari districts sloping towards the coast. In Srikakulam and Visakhapatnam districts, the thickness varies up to 20 m.

5. GROUND WATER RESOURCES (2012-2013)

The dynamic ground water resource potential of the state has been estimated as per the methodology given by the Ground Water Estimation Committee 1997 (GEC 1997).

As per the latest estimates (March 2013), the annual replenishable ground water resources are 20387 MCM, natural discharge during non-monsoon period is 1913 MCM, net ground water availability is 18474 MCM, annual gross ground water draft is 8104 MCM, allocation for future domestic and industrial use is 1644 MCM and net ground water availability for future irrigation use is 10210 MCM. The average stage of ground water development is 44 %.

Out of 670 mandals, 61 fall under over-exploited category(OE), 17 falls under critical(C), 54 under semi-critical(SC) and rest 538 under safe category (this includes 73 poor quality mandsls (41 Fully and 32 partly). More mandals from Rayalseema regions falls under OE, C and SC category than Coastal region mandals. The categorization of mandals is depicted in **Fig.5.1**.

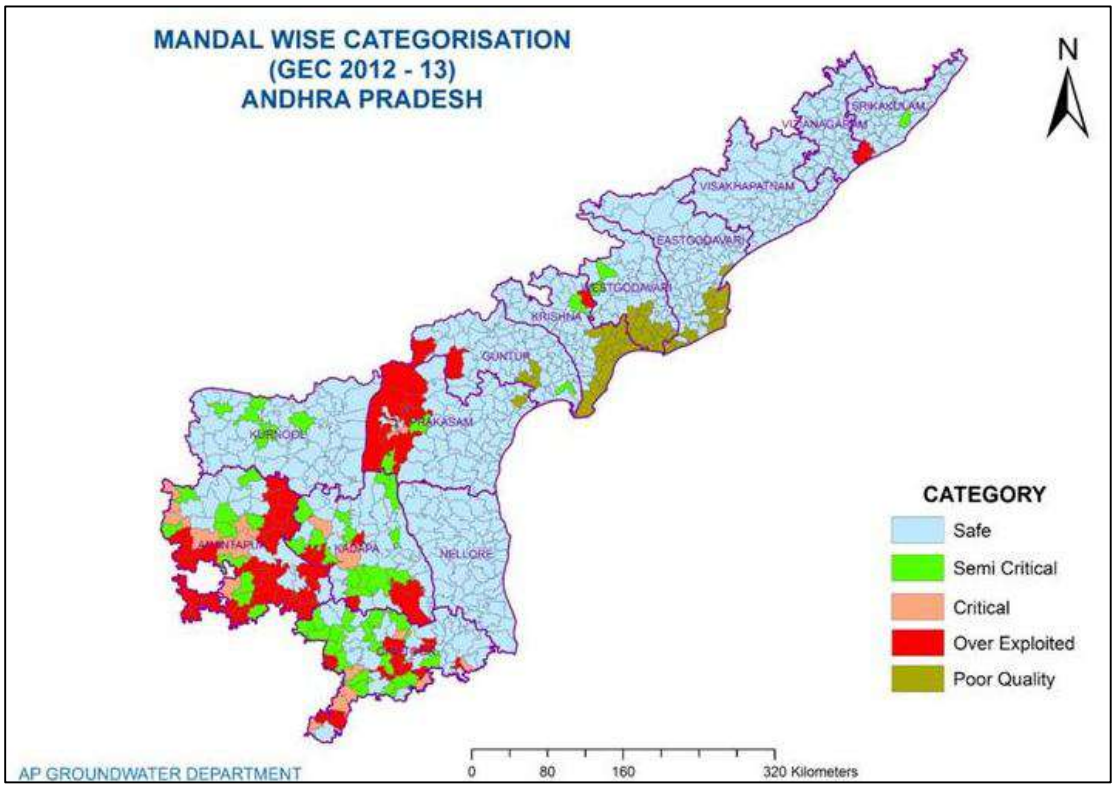

Fig.5.1: **Categorization of Mandals (as on March, 2013), Andhra Pradesh State.**

6. GROUND WATER REGIME MONITORING

Ground water level monitoring is a scientific surveillance system to establish the periodic and long-term changes in ground water regime. The water level data over a period of time provides information on changes in ground water levels with progressive ground water development by natural and artificial recharge/surface water irrigation system.

Monitoring of a network of ground water monitoring wells provides periodical information on ground water regime scenario with a fair degree of accuracy in different hydrogeological environments in the area.

Ground water occurrence point of view State litho units are grouped in to following 3 groups.

i) Consolidated Formations
ii) Semi-consolidated Formations
iii) Unconsolidated Formations

6.1 Consolidated formations: Crystalline rocks of Archaean age, metasedimentary rocks of Cuddapah and Kurnools and basalts lava flows of Deccan traps are included in these formations occupying ~83% of the area. These rocks generally lack primary porosity and secondary porosity is developed due to weathering, fracturing, development of solution cavities and channels and interconnection of vesicles. In these rocks depth of weathering varies from 5 to 10 m bgl (occassionaly up to 20 m) and majority of fractures occur with in 100 m depth. In these rocks dug wells/ dug cum bore wells and bore wells are the most prevalent abstraction structures. Ground water yield from these rocks varies from 0.1 lps to 3 lps.

In Khondalite formations, depth of weathering varies from 10-40 mbgl with yields of 0.5-2 lps.Consolidated meta-sedimentary formations (Cuddapah and Kurnool rocks and equivalents) has undergone great deal of compaction, metamorphism, thereby reducing primary porosity. Occurrence of ground water in these formations is restricted to structural features like folds, faults, lineaments, fractures, fissures, solution cavities and channels etc. Depth of weathering in these formation ranges from 5-10 m bgl and yield varies from 0.01-19 lps (general 1-5 lps). Relatively Kurnool group of rocks are more potential than other Cuddapahs (general yield 5-10 lps).

6.2 Semi-consolidated formations: Semi-consolidated formations are represented by rocks belonging to Gondwana formations (sandstones) and Rajahmundry sandstones. The yield of these formations ranges from 10-70 lps.

6.3 Unconsolidated formations: Un-consolidated formations are represented by coastal alluvium, deltaic alluvium and inland river alluvium. Ground water occurs under water table and confined conditions. Water quality in deeper aquifers is of poor quality. In deltaic areas of Godavari, Krishna and Pennar, yield varies from 0.7-30 lps and Godavari deltas. Ground water quality is of potable nature in paleochannels.

6.4 Monitoring Methodology

Ground water regime is monitored through a network of dug wells and piezometers known as Ground Water Monitoring Station (GWMS). The dug wells, which are owned by government , non-government agencies and individual users, are tapped in the shallow aquifer system. Piezometers (basically bore wells/tube wells) are constructed exclusively for ground water regime monitoring under Hydrology Projected. Some of the exploratory wells/ onservatory wells drilled under and exploratory drilling programme of Central Ground Water Board are converted to piezometers for regular monitoring.

The network of observation wells are monitored 4 times a year by the officials of Central Ground Water Board during the following periods.

Period	**Date**
January	1st to 10th of the month
May (Pre-monsoon)	20th to 30th of the month
August (Mid-monsoon)	20th to 30th of the month
November (Post-monsoon)	1st to 10th of the month

6.4.1 Participatory Ground water Monitoring

Weekly water level measurements are initiated in phases involving local people as observers under participatory ground water monitoring programme, to observe micro-level changes in ground water regime. Participatory observers from the local area where GWMS is

theres are engaged since May, 2005 and as on 31st March, 2018 , 151 nos of GWMS are monitored though participatory approach (**Table-6.1**).

6.4.2 Chemical Quality Monitoring

The chemical quality of ground water is monitored (dug wells/Piezometers) once in the month of May (pre-monsoon season) to observe the effect of geogenic, anthropogenic contamination on ground water in different hydrogeological environments over a period of time.

6.5 Maintenance of Database on Ground Water Monitoring Wells

The database on water levels and chemical quality is entered in the GEMS, developed over a period of time since 1969. The database is maintained in Oracle using GEMS (Ground water Estimation and Management System) software, which is adopted by all ground water agencies in the country.

6.6 Distribution of Ground Water Monitoring Wells

The distribution and density of monitoring wells in the State; distribution in river basins, aquifer systems and canal command areas are summarized in the the following session.

6.6.1 District-Wise Distribution of Ground Water Monitoring Wells

Total 875 GWMS are monitored in the state (DW: 727 (83 %) and Pz: 148 (17%) and density varies from 102 Km^2/well (East Godavari) to 310 Km^2/well in Kurnool district (**Table-6.1**).

6.6.2 Aquifer-Wise Distribution of Ground Water Monitoring Wells

Out of 875 GWMS, 610 wells are located in hard rocks, 245 wells in soft rocks. District wise and aquifer wise distribution of GWMS is given in **Table-6.2.** About 23.8 % of GWMS are located in Banded Gneissic complex , followd by Alluvium formations (23.3 %), followed by Khondalite rocks (10.3 %) .

Table-6.1: District-wise Distribution of GWMS, Andhra Pradesh State (As on March, 2018).

S. No.	District	Area (Km2)	No of GWMS			No of Participatory	Density of Network stations (sq. km. per well)		
			DW	Pz	Total	Nos	Dug wells	Piezo meters	combined stations
1	Anantapur	19130	35	33	68	18	547	580	281
2	Chittor	15152	48	10	58	15	316	1515	261
3	Cuddapah	15359	28	26	54	11	549	591	284
4	East Godavari	10807	93	13	106	13	116	831	102
5	Guntur	11391	85	13	98	18	134	876	116
6	Krishna	8727	67	7	74	11	130	1247	118
7	Kurnool	17658	38	19	57	17	465	929	310
8	Nellore	13076	59	1	60	7	222	13076	218
9	Prakasam	17626	50	14	64	9	353	1259	275
10	Srikakulam	5837	53	0	53	4	110	Nil	110
11	Vishakhapatnam	11161	63	3	66	17	177	3720	169
12	Vizianagaram	6539	51	0	51	3	128	Nil	128
13	West Godavari	7742	57	9	66	8	136	860	117
	Total	**160205**	**727**	**148**	**875**	**151**	**220**	**1082**	**183**

Nine Dug wells and One Piezometers are transferred from erstwhile Telangana state to Andhra Pradesh.

Table-6.2: Distribution of monitoring stations-Principal Aquifer-wise (as on March, 2018).

		AL		BG		CK		GN		GR		KH		LS		LT		QZ		SC		SH		ST		IN	TOTAL
S NO	**DISTRICT**	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***Dw***	***PZ***	***PZ***	
1	Ananthapur			22	26					12	5											1	2				68
2	Chittor	2		43	10											3											58
3	Cudapah			8	3									1	5			3	1	1		15	16			1	54
4	East Godavari	45	8	5	1	8		8		1		19	1											7	3		106
5	Guntur	26		14	3	20	1			1				11	4			2	1	5	2	3	1	3	1		98
6	Krishna	39	2	14		5	2					7	2		1									2			74
7	Kurnool			10	8			1	3	5	4			9	4			3				10					57
8	Nellore	16		6		1				1						2		1		32	1						60
9	Prakasam	12	1	2	1	9	3	5	2	2	2						1			9	4	8		3			64
10	Srikakulam	12		28		5		5				3															53
11	Vijaianagaram					9		21				21															51
12	Visakapatnam	1				21		11				29	3	1													66
13	West Godavari	36	4	5				1				5												10	5		66
	TOTAL	189	15	157	52	78	6	52	5	22	11	84	6	22	14	5	1	9	2	47	7	37	19	25	9	1	875
		Nine Dug wells and One Piezometers are transferred from earstwhile Telangana state to Andhra Pradesh.																									

(Note:AL: Alluvium, BGC-Banded Gneissic complex, CK-Charnokite, Gn-Gneiss, Gr-Granite, Kh-Kondalite, LS-Limestone, LT-Laterite, Qz-Quartzite,SC-Schists, SH-Shale, ST-Sandstone).

7. ANALYSIS OF WATER LEVELS

The ground water levels observed over a period of time provide valuable information on behaviour of the ground water regime, which is constantly subjected to changes due to recharge and discharge phenomena. A balance between these two factors results in the decline or rise in the ground water storage. When the recharge exceeds discharge there will be a rise in the ground water storage and vice versa. The decline in water level may be due to increase in draft (for different purposes) or decrease in precipitation (less recharge to ground water). On the other hand a rise in water level may be due to an increase in rainfall and/or due to changes in irrigation practices. The dug wells tap the phreatic aquifer mostly limited to a depth of 20 m. The depth of piezometers which are tapping both the phreatic and deeper aquifers varies from 20 to 100 m. Hence the water level recorded in the piezometers may not be the same as that of dug wells for a particular period though both the structures are in the same place. In this report the water level data collected from un-confined aquifers (shallow depth) is presented. An attempt is also made to interpret the piezometric data generated by SGWD and CGWB and piezometric maps of May and Nov 2017 are prepared. The data from GWMS for the year 2017-18 was analysed and for every set of measurements, write up and maps were prepared and are presented here under various paragraphs. The purpose of water level data analysis is

i) Four measurements of depth to water level give an overall idea regarding the ground water level in the state during the year of measurement.

ii) The fluctuation in comparison to the same month in the previous year gives an idea about the change in the ground water level for a particular period with respect to that of the level during the same month in the previous year. This gives an idea about the change in the amount of draft and rainfall between the two years.

iii) The water level fluctuation during the pre-monsoon period in comparison to last year gives an idea about the seasonal fluctuation, which ultimately reflects the change in dynamic ground water resources.

iv) The water level fluctuation during a particular month of measurement with reference to the decadal mean for the same months gives an idea of the behaviour of the ground water level on long-term basis.

7.1 Depth to Water Levels

7.1.1 Depth to Water Levels (May, 2017)

The depth to water level during May, 2017 monitoring based on analysis of water level data of 751 wells is generalized and given below. The spatial distribution of depth water levels is shown in Fig **7.1.**

An analysis of depth to water level data of 751 wells **(Annexure - V**) shows water levels vary between -0.25 m.bgl (Krishna district) and 49.3 m.bgl (Prakasam district). Water level of less than 2 m bgl is recorded in 6 % of wells, between 2-5 m bgl in 37% of wells, between 5-10 m bgl in 41% of wells, between 10-20 m bgl in 15% of wells , between 20-40 m bgl in 1% of wells and in the rest 0.4% of wells depth to water level more than 40 m bgl is registered. Depth to water level map of May, 2017 (**Fig.7.1**) shows that , area-wise 71% of the state is covered by depth to water level of 0 to 10 m bgl. Shallow water levels of less than 2 m bgl are noticed in very small parts (1%) in Kurnool, Guntur, Krishna and Visakhapatnam districts. Deeper water levels of more than 20 m covers about 5% of the state noticed mostly in Rayalaseema districts, .

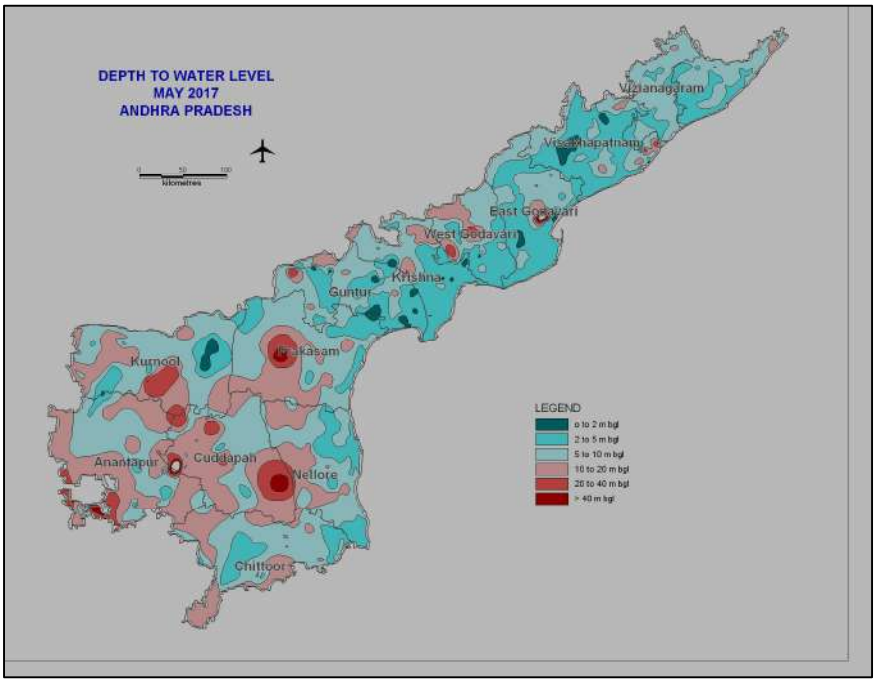

Fig.7.1: Distribution of water levels, Premonsoon season (May, 2017).

7.1.2 Depth to Water Levels –August, 2017 (Mid-monsoon Season)

The depth to water levels are summarized below and presented as pie diagram (**Fig. 7.2).** An analysis of depth to water level data of 745 wells **(Annexure-VI**) shows, water levels are in the range of -0.36 (Guntur district) 47.5 mbgl(YSR Kadapa district). One well located at in Guntur district shown artesian conditions (-0.36 m). Shallow water level in the range of 0 to 2 m bgl covers an area of about 21,190 Km^2 (14% of state area) and mostly observed in north coastal districts and small parts of Kurnool and Nellore districts in 31% of the wells. Water levels in the range of 2 to 5 m occupies about 42,850 Km^2 areas (28% of the total geographical area of the state), occupying mostly eastern and northern part of the State in 31% of the wells except Rayalaseema district. Majority of the water levels are in the range of 5 to 10 m bgl occupying about 51,000 Km^2 (33% of the state area) in 26% of the wells.Water levels between 10-20 m bgl cover about 33,190 $Km^2$of state area(22 %) in 11% of the wells. Deep water levels in the range of more than 20 mbgl covers about 4,611 Km^2 area (3.13 %) of the total geographical area respectively, covering parts of Rayalaseema region and Prakasam districts in 1.13% of the wells. Deep water levels more than > 20 mbgl covers about 7.3 % of the total geographical area covering parts of Kadapa, Anantapuramu and Kurnool districts in 1.38% of the wells.

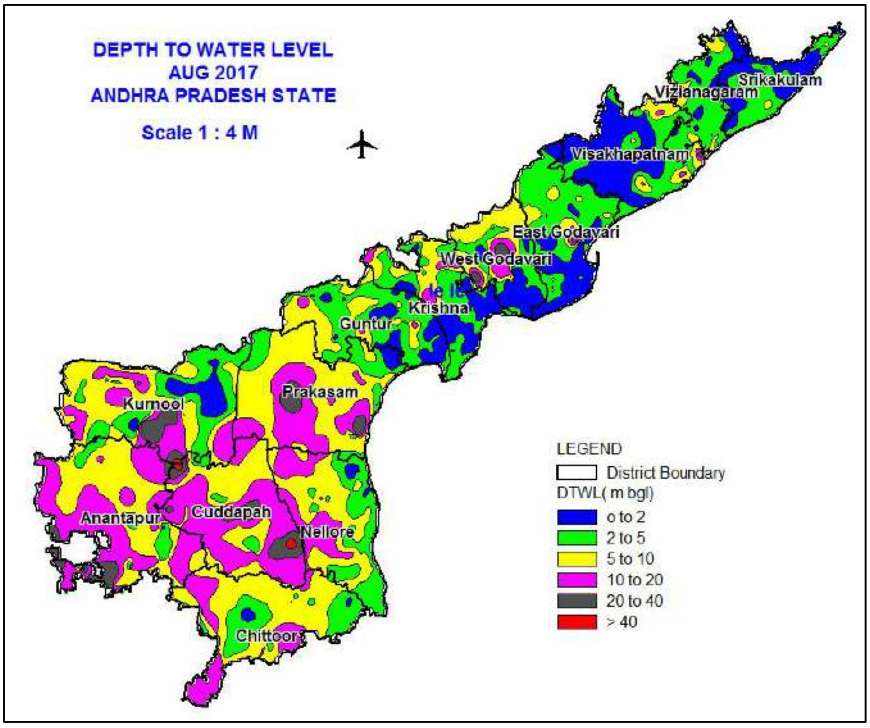

Fig.7.2: Depth to Water Levels in August, 2017 (Mid-monsoon season).

7.1.3 Depth to Water Levels - Post-Monsoon Season (November, 2017)

An analysis of depth to water level data of 824 wells (751 unconfined aquifer and 73 in (confined and semi-confined aquifer) is presented in **(Annexure-VII)**. Spatial distribution of water levels in the state is shown in **Fig 7.3**. Water levels are in the range of -0.80 m bgl (artesian well, Krishna district) to 39.5 m bgl(Guntur district) in unconfined aquifer and -0.28m bgl (artesian well , Kurnool district) to104.4 m bgl (Anantapur district) .One well located at in Krishna district and Kurnool district each shown artesian conditions.

Shallow water level in the range of 0 to 2 m bgl covers an area of about 20,990 Km^2 (13% of state area) and mostly observed in coastal belt and small parts of Kurnool (262 wells).Water levels in the range of 2 to 5 m occupies about 32,520 Km^2 (21% of the total geographical area of the state), occurring in all coastal districts , except Prakasam district, in the coastal belt and as isolated small patches in Rayalaseema districts. entire State except parts of southern areas of the state. Majority of the water levels are in the range of 2 to 10 m bgl occupying about 68 % of the area in 1,07,180 sq.k. This is due to normal to excess rainfall in the state during the period i.e., June to October . Deep water levels in the range of >=20 mbgl covers 3095 Km^2 area (2 %) of the total geographical area as small parts of Kadapa, Anantapur, Kurnool, Prakasam and Guntur districts.

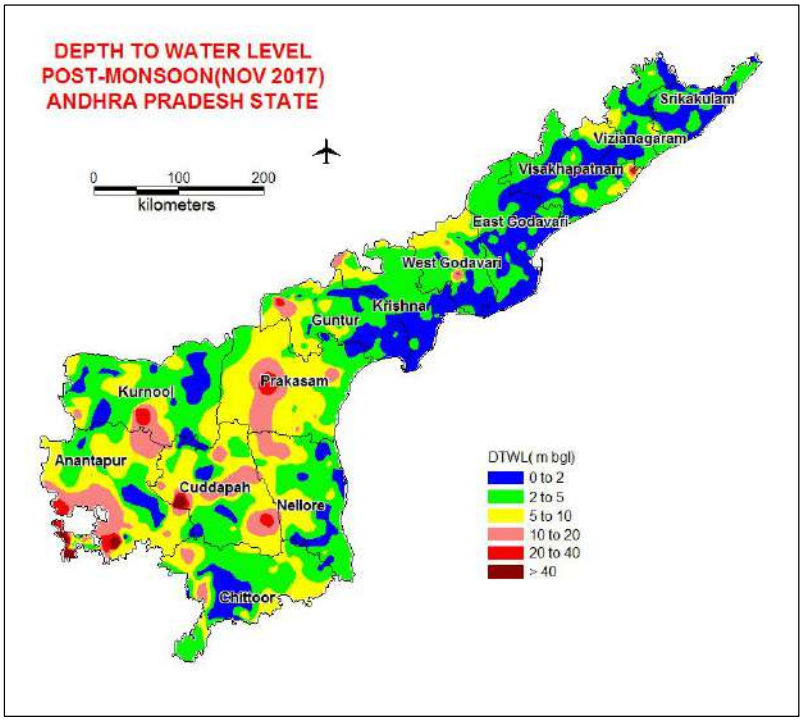

Fig.7.3: Depth to Water Levels – Nov, 2017 (Post-monsoon season)

7.1.4 Depth to Water Levels (January, 2018)

An analysis of depth to water level data of 825 wells with district-wise minimum, maximum and average along with percentage and number of wells in different depth ranges sis presented in **(Annexure-VIII**). Spatial distribution of water levels in the state is shown in **Fig 7.4**. The average water level of the state is 5.70 m ranging from 3.10 m bgl in Srikakulam and 11.78 m in Anantapur district. Water levels are in the range of -0.70 m bgl (artesian well, Nellore district) to 104.4 m bgl(Anantapuramu district).

Shallow water level in the range of 0 to 2 m bgl covers an area of about 17,690 Km^2 (11%) area) and mostly observed in coastal areas of East Godavari, West Godavari, Krishna, Guntur , and small parts of Kurnool , Anantapuramu and Visakhapatnam districts. Water levels in the range of 2 to 5 m occupies about 70,410 Km^2 (43%), occurring in all districts , except Prakasam district, Water levels are in the range of 5 to 10 m bgl occupy about 33 % of the area in 54,520 sq.km. This is due to normal to excess rainfall in the state during the period i.e., June to December . Deep water levels in the range of >=20 mbgl covers 4737 Km^2 area (3 %) as small parts of Rayalaseema districts and Prakasam district.

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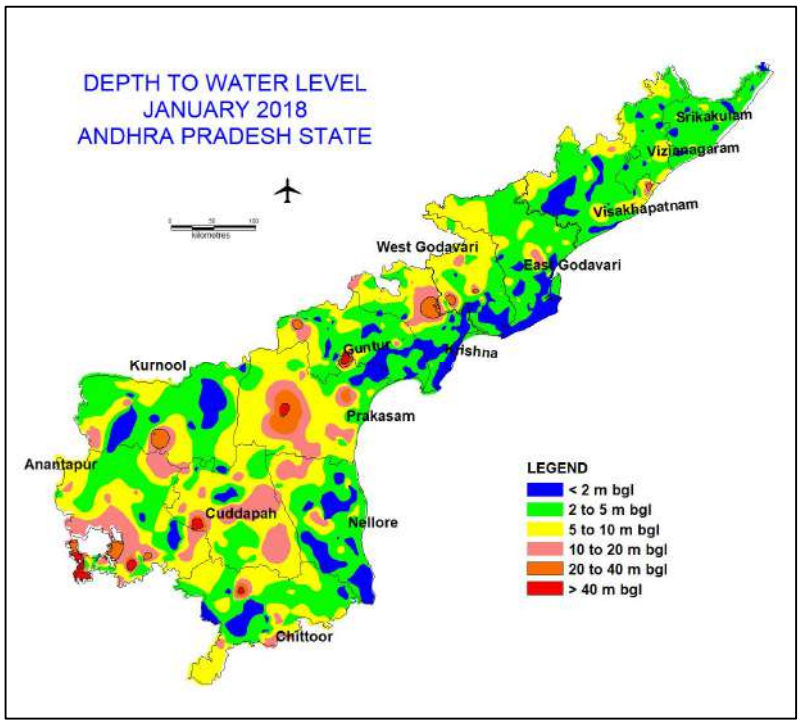


Fig.7.4: Depth to Water Levels- January, 2018.

7.2 Integrated Depth To Water Level (GWD and CGWB)

The water level data of monitoring stations (Piezometers only) of Central Ground Water Board and State Ground Water Board are considered together to analyze the water level data of the monitoring stations in the state.

7.2.1 May 2017 (Pre-monsoon) Water level data from a total of 1176 station, out of which, 1082 stations of State GWD and 94 of CGWB are utilized for preparing the depth to water level map **(Fig 7.5)** and the depth to water levels and percentage of wells in different depth ranges in May 2017. Based on the tabulated **(Table 7.1)** results, it is inferred that, out of 1176 stations, depth to water level of 32 stations (3%) are in the range of 0 to 2 m bgl, 205 stations (17%) are in the range of 2 to 5 m bgl, 339 stations (29%) are in the range of 5 to 10 m bgl, 309 stations (26%) are in the range of 10 to 20 m bgl, 206 stations (18%) are in the range of 20 to 40 m bgl and depth to water level of 85 stations (7.2%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 25.2 % of wells and shallow water level of less than 2 m bgl are observed in 3 % of wells. Area-wise, 28% of the state have deeper water levels(>20 m bgl) and only 2% of the area has shallow water levels. Medium range 5-20 m bgl is observed in 60% of the area.

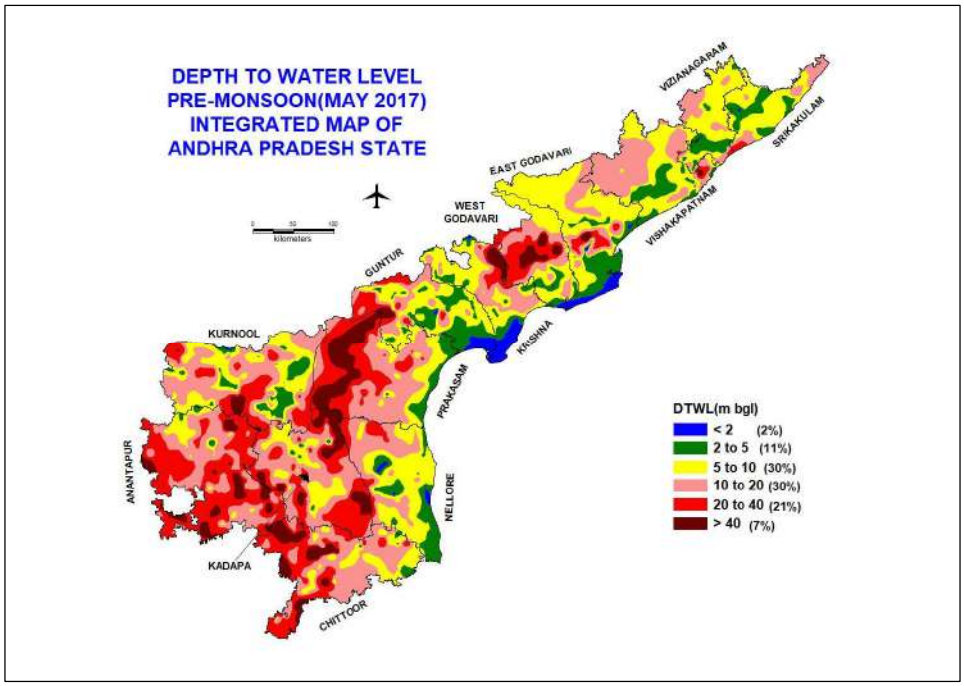


Fig 7.5 Depth To Water Level Map of May 2017 (Integrated data)

TABLE 7.1 DEPTH TO WATER LEVELS AND PERCENTAGE OF WELLS IN DIFFERENT DEPTH RANGES IN MAY , 2017

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	0 TO 2	% OF WELLS	2 TO 5	% OF WELLS	5 TO 10	% OF WELLS	10 TO 20	% OF WELLS	20 TO 40	% OF WELLS	> 40	% OF WELLS
1	SRIKAKULAM	35	1.43	26.00	7.90	1	3%	9	26%	17	49%	7	20%	1	3%	0	0%
2	VIZIANAGARAM	38	1.55	17.56	7.05	1	3%	11	29%	18	47%	8	21%	0	0%	0	0%
3	VISAKHAPATNAM	67	1.30	45.20	9.61	1	1%	16	24%	24	36%	23	34%	2	3%	1	1%
4	EAST GODAVARI	91	0.35	67.65	9.27	8	9%	27	30%	34	37%	10	11%	11	12%	1	1%
5	WEST GODAVARI	63	1.79	75.09	21.86	1	2%	7	11%	15	24%	14	22%	18	29%	8	13%
6	KRISHNA	94	1.36	89.80	11.29	4	4%	17	18%	39	41%	23	24%	8	9%	3	3%
7	GUNTUR	119	0.88	64.70	9.48	7	6%	42	35%	43	36%	15	13%	10	8%	2	2%
8	PRAKASAM	95	2.77	76.59	20.05	0	0%	14	15%	17	18%	30	32%	19	20%	15	16%
9	NELLORE	77	1.24	35.43	9.37	4	5%	15	19%	29	38%	24	31%	5	6%	0	0%
10	CHITTOOR	108	1.51	98.40	22.68	1	1%	3	3%	24	22%	40	37%	27	25%	13	12%
11	KADAPA	104	1.96	113.90	23.56	1	1%	4	4%	26	25%	27	26%	29	28%	17	16%
12	ANANTAPUR	146	3.61	82.23	24.41	0	0%	4	3%	14	10%	50	34%	58	40%	20	14%
13	KURNOOL	139	1.28	49.66	12.05	3	2%	36	26%	39	28%	38	27%	18	13%	5	4%
	STATE FIGIURES	**1176**	**0.35**	**113.90**	**15.61**	**32**	**3%**	**205**	**17%**	**339**	**29%**	**309**	**26%**	**206**	**18%**	**85**	**7.2%**

7.2.2 Post-monsoon (November 2017)

The water level data of monitoring stations (Piezometers only) of Central Ground Water Board and State Ground Water Board are considered together to analyze the water level data of the monitoring stations in the state. Water level data from a total of 1213 station, out of which, 1087 stations of State GWD and 126 of CGWB are utilized for preparing the depth to water level map **(Fig 7.6)** and the depth to water levels and percentage of wells in different depth ranges in Nov 2017. Based on the tabulated **(Table 7.2)** results, it is inferred that, out of 1213 stations, depth to water level of 196 stations (16%) are in the range of 0 to 2 m bgl, 315 stations (26%) are in the range of 2 to 5 m bgl, 305 stations (25%) are in the range of 5 to 10 m bgl, 258 stations (21%) are in the range of 10 to 20 m bgl, 102 stations (8%) are in the range of 20 to 40 m bgl and depth to water level of 37 stations (3.1%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 11.1 % of wells and shallow water level of less than 2 m bgl are observed in 16 % of wells. Area-wise, 10% of the state have deeper water levels and only 7% of the area has shallow water levels. Medium range 5-10 m bgl is observed in 32% of the area. There is not much change in the medium range of depth to water levels (5-10 m ngl). From pre-monsoon to post-monsoon, there is drop from 28% to 10% in the deeper water level range and there is an increases from 2% to 7% in shallow water levels due to good monsoon rains.

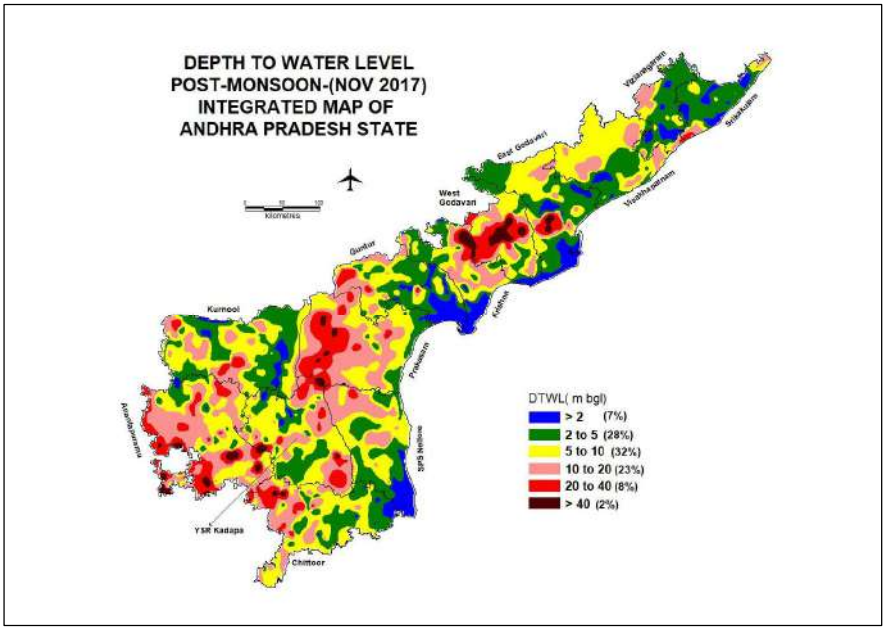


Fig 7.6 Depth To Water Level Map of Nov 2017 (Integrated data)

TABLE 7.2 DEPTH TO WATER LEVELS AND PERCENTAGE OF WELLS IN DIFFERENT DEPTH RANGES IN NOVEMBER , 2017

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	0 TO 2	% OF WELLS	2 TO 5	% OF WELLS	5 TO 10	% OF WELLS	10 TO 20	% OF WELLS	20 TO 40	% OF WELLS	> 40	% OF WELLS
1	SRIKAKULAM	35	0.79	24.52	4.25	12	34%	15	43%	4	11%	3	9%	1	3%	0	0%
2	VIZIANAGARAM	38	0.68	15.80	4.29	11	29%	17	45%	7	18%	3	8%	0	0%	0	0%
3	VISAKHAPATNAM	66	0.60	28.80	7.04	10	15%	17	26%	25	38%	12	18%	2	3%	0	0%
4	EAST GODAVARI	95	0.21	66.62	7.57	21	22%	33	35%	22	23%	11	12%	6	6%	2	2%
5	WEST GODAVARI	64	1.57	74.74	18.77	2	3%	14	22%	15	23%	13	20%	12	19%	8	13%
6	KRISHNA	94	0.05	81.78	9.49	19	20%	23	24%	19	20%	24	26%	6	6%	3	3%
7	GUNTUR	123	0.57	39.50	6.51	37	30%	37	30%	24	20%	20	16%	5	4%	0	0%
8	PRAKASAM	94	0.94	59.86	13.42	4	4%	15	16%	28	30%	31	33%	11	12%	5	5%
9	NELLORE	77	0.23	33.40	6.22	24	31%	15	19%	23	30%	14	18%	1	1%	0	0%
10	CHITTOOR	108	0.36	51.49	9.64	12	11%	28	26%	30	28%	27	25%	8	7%	3	3%
11	KADAPA	118	-0.08	99.50	11.47	13	11%	24	20%	34	29%	28	24%	15	13%	4	3%
12	ANANTAPUR	157	0.19	104.40	16.84	4	3%	17	11%	39	25%	54	34%	32	20%	11	7%
13	KURNOOL	144	-0.30	43.45	6.14	27	19%	60	42%	35	24%	18	13%	3	2%	1	1%
	STATE FIGIURES	**1213**	**-0.30**	**104.40**	**9.936**	**196**	**16%**	**315**	**26%**	**305**	**25%**	**258**	**21%**	**102**	**8%**	**37**	**3.1%**

7.3 FLUCTUATIONS WITH PREMONSOON WATER LEVELS

7.3.1 Water Level Fluctuation- From May, 2017 to Aug 2017

Water level fluctuations during August 2017 from May 2017 are presented in **Annexure-IX.** An analysis of 722 wells shows that water level rise is recorded in 77 % wells (559 nos) . About 12% of wells (90 nos) have shown a fall in water level. About 10% of the wells have not shown any change in the water levels. These are dry wells, which have not shown any change in water levels. Spatial distribution is given in **Fig 7.7.** The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in Kurnool and 22.4 m in Prakasam districts. The minimum and maximum fall in water level fluctuations is recorded in 0.01 m in West Godavari and 26.8 m in Prakasam district. Rise in water levels is in 77% of the wells covering entire state except parts of Rayalaseema region and Prakasam district. Water level fall is in only 12% of the wells and fall of more than 4 m is as small patch in Prakasam , Anantapuramu and and Nellore districts. Rise of more than 4 m is recorded mainly in north coastal districts and western parts of West Godavari, Krishna and Guntur districts.

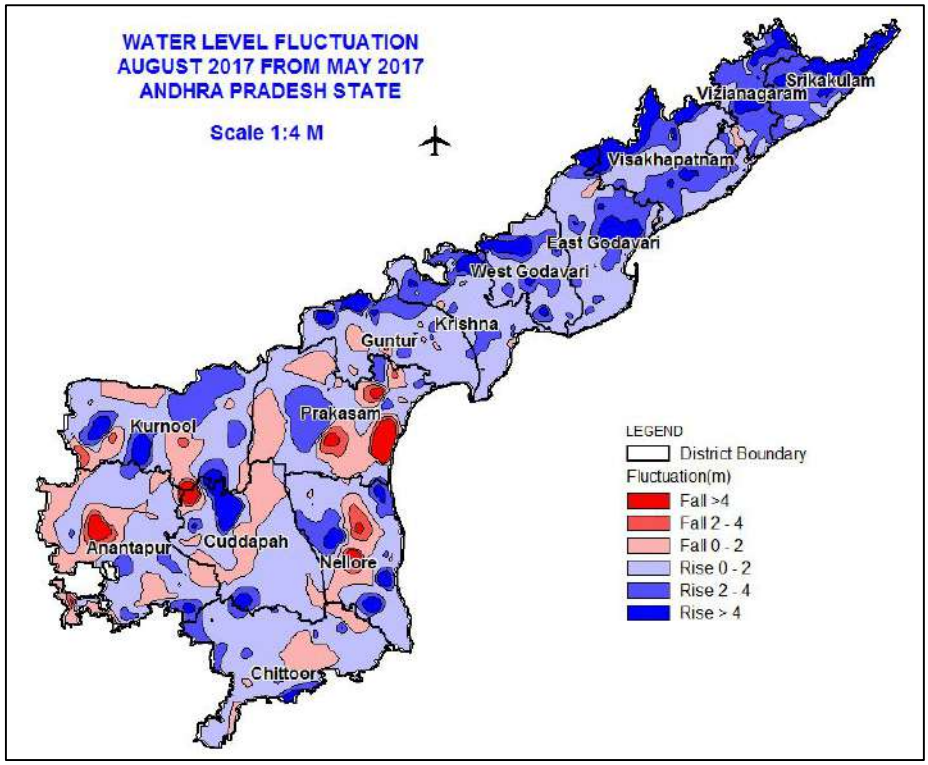


Fig 7.7 Water Level Fluctuation (From May 2017 to August 2017)

7.3.2 Water Level Fluctuation - from May, 2017 to Nov, 2017

The district-wise water level fluctuations from May 2017 to Nov 2017 are presented in **Annexure-X.** An analysis of 716 wells shows that water level rise is recorded in 91 % wells (650 nos) and 6% of wells (46 nos) have shown a fall in water level and 3% of wells (20 nos) have no rise or fall in water levels. Rise in water levels is mainly due to normal to excess rainfall during the period June to October 2017, specially the Rayalseema region received 18% to 43 % more than normal rainfall. Spatial distribution water level fluctuation is shown in **Fig 7.8.**

The minimum and maximum rise in water level fluctuations is recorded as 0.04 m in SPS Nellore district and West Godavari and 18.58 m in Prakasam district. The minimum and maximum fall in water level fluctuations is recorded as 0.01 m in East Godavari and Guntur district and 15.7 m in Krishna district. In the state, rise of more than 4 m is observed in Rayalaseema districts and Srikakulam districts. Water level fall of more than 4 m is observed in Anantapur, Prakasam and Krishna district. Water levels rise in the ranges 0 to 2 m and 2 to 4 m is more prominently seen in about 275 well (38%) and 1875 wells (26%), respectively.

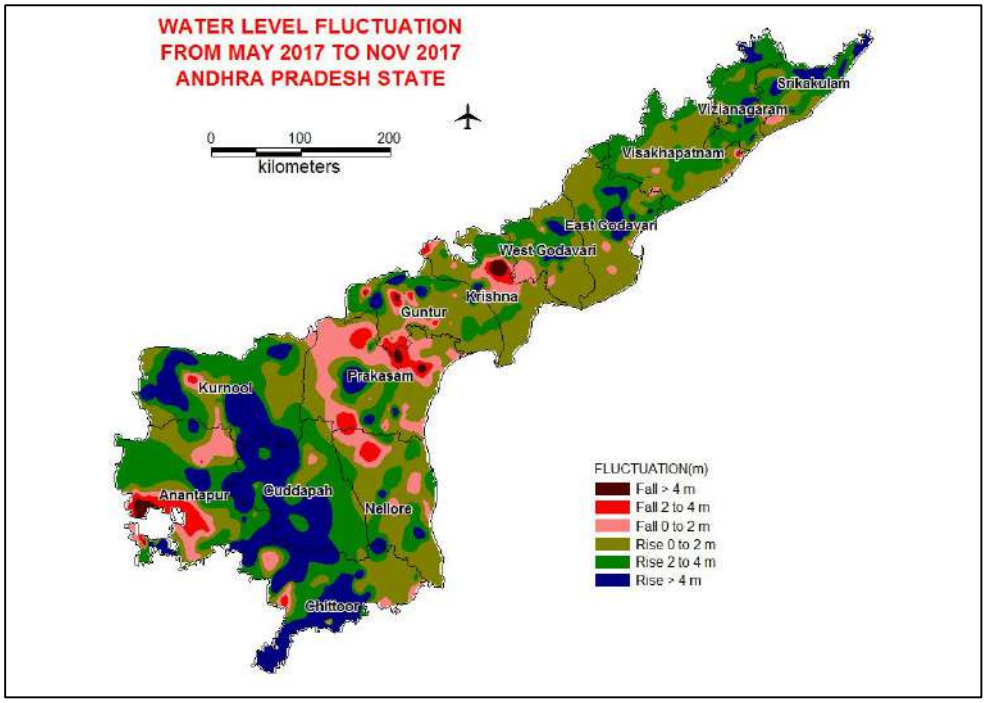


Fig 7.8 Water Level Fluctuation (Nov, 2017 from May, 2017)

7.3.3 Water Level Fluctuation - from May, 2017 to January 2018

The district-wise water level fluctuations from May 2017 to Jan 2018 are presented in **Annexure-XI.** An analysis of 752 wells shows that water level rise is recorded in 90 % wells (676 nos) and fall in water levels in 10% of wells (76 nos) . Rise in water levels is mainly due to normal to excess rainfall during the period June to December 2017, specially the Rayaseema region received 10% to 24 % more than normal rainfall. Spatial distribution of water level fluctuations is shown in **Fig 7.9.**

The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in most parts of the state and maximum of 28.6 m in Anantapuramu district respectively. The minimum and maximum fall in water level fluctuations is recorded as 0.01 m in Anantapuramu and Kurnool districts and maximum of 24.66 m in Prakasam district. In the state, rise of more than 4 m is observed in 103 wells (15% of total wells) predominantly in Rayalaseema districts and Srikakulam districts which is due to good rains . Water level fall of more than 4 m is observed in 13 wells in Prakasam and Krishna districts

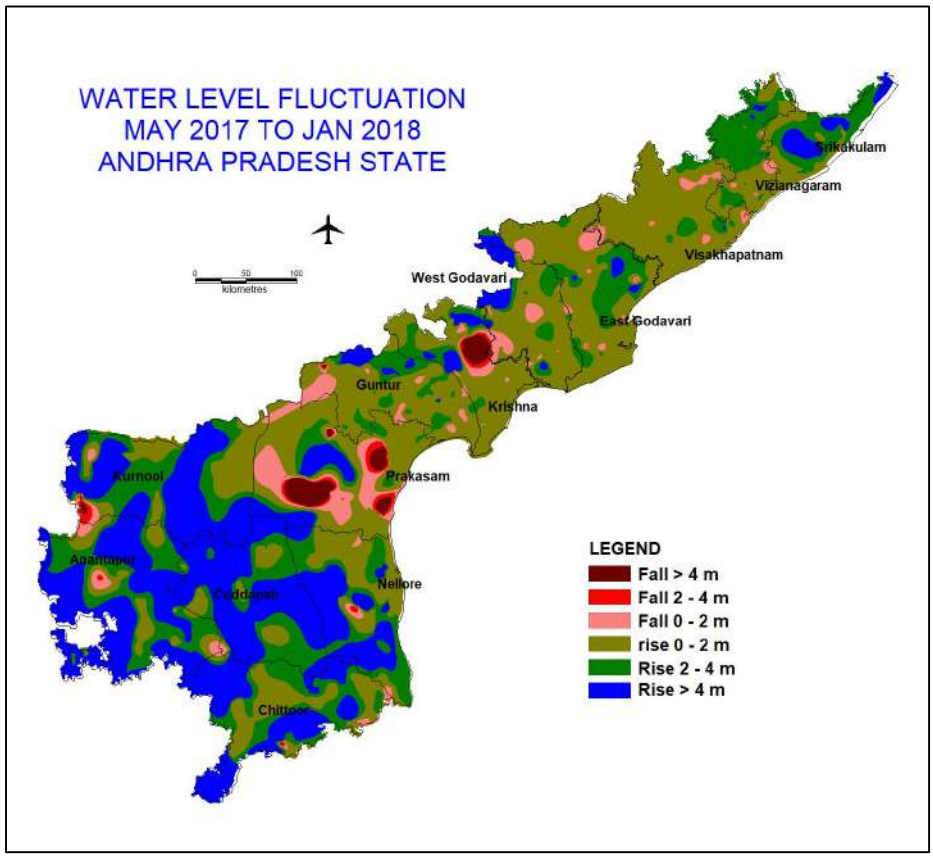


Fig 7.9 Water Level Fluctuation (May, 2017 to January, 2018)

7.4 Annual Water Level Fluctuation

7.4.1 Water Level Fluctuation (From May 16 to May, 2017)

Water level fluctuation data of May 2017 with May 2016 is presented in **Annexure - XII.** An analysis of data of 741 wells shows that water level rise is recorded in 29% of wells (216), water level fall is recorded in 63% of wells (465), while in the rest 8.0% of wells (60) zero fluctuation is recorded. This is mainly due to 23.5% less rainfall in 2016 monsoon compared to monsoon 2015. Spatial distribution of fluctuation is shown in **Fig 7.10.**

Area-wise, 35% of the state experienced water levels rise compared with the same period last year. Out of the 216 wells that have registered a rise in water levels, 22% of wells recorded water level rise of less than 2 m, 3% of wells in the range of 2 to 4 m while the rest 3% of wells recorded water level rise of more than 4 m. Rise in water level of less than 2 m is observed mostly in western parts of the state except Chittoor, Kadapa and Nellore. Rise of water level more than 4 m is observed as patches in Kurnool, Prakasam, East and West Godavari and Krishana districts.

Area-wise, 65% of the state experienced water levels fall compared with the same period last year Out of the 465 wells that have registered fall in water levels, 42% of wells have recorded less than 2 m fall, 13% of wells in the range of 2-4 m and the rest 8% wells registered water level fall more than 4 m. Rayalaseema districts, except in some parts of Kurnool , and as isolated parts in all the coastal districts have patches with water level deeper water levesl than May, 2016 . Fall of water level more than 4 m is more prominent in Nellore, Chittoor, Anantapuramu and Kadapa districts.

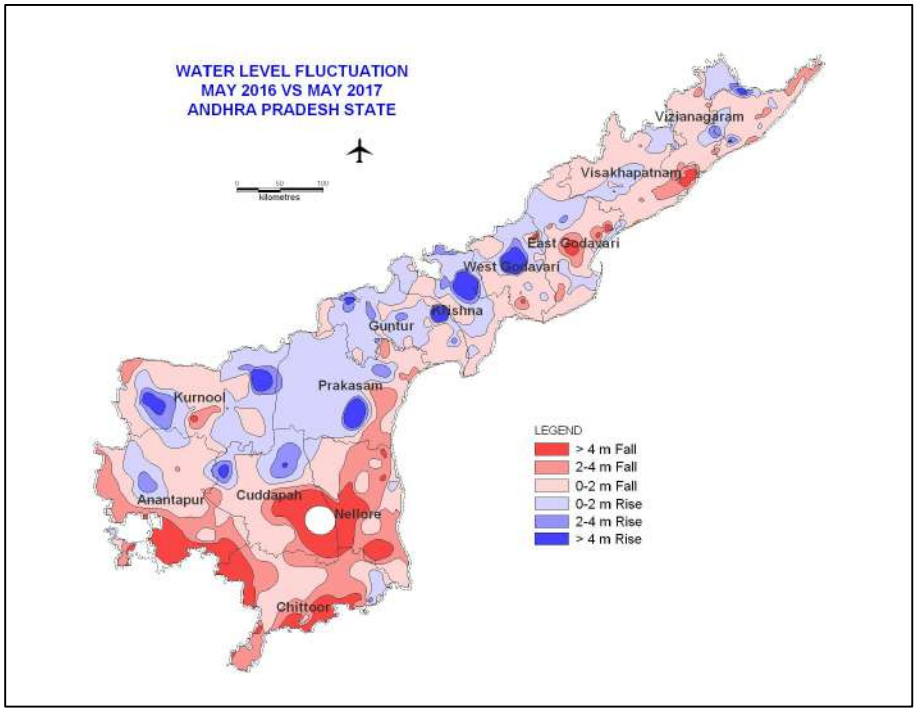


Fig.7.10: Water Level Fluctuations (May, 2017 from May, 2016)

7.4.2 Water Level Fluctuation (August-2017 from August-2016)

Water level fluctuation data of August 2017 from August 2016 is presented in **Annexure-XIII.** An analysis of 721 wells shows that water level rise is recorded in 42% of the wells (301 nos) and in 54% of the wells (390 nos) have shown a fall in water levels. About 30 wells have shown neither rise nor fall in water levels (dry wells in both the seasons). Spatial distribution of fluctuation is shown in **Fig 7.11.**The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in Kurnool district and 22.4 in Prakasam districts.The minimum and maximum fall in water level fluctuations is recorded in 0.01 m East Godavari district and 27.1 m in Prakasam district respectively. Rise in water levels is noticed in 42% of the wells covering entire state except parts of Rayalaseema region. Water level fall is 54% of the wells covering most parts of the Rayalaseema region and parts of East Godavari and West Godavari districts. Fall of more than 4 m is observed significantly in southern parts of Rayalaseema region and Prakasam distinct. Rise of more than 4 m is recorded mainly in central parts of Prakasam district and western parts of Krishna and Guntur districts

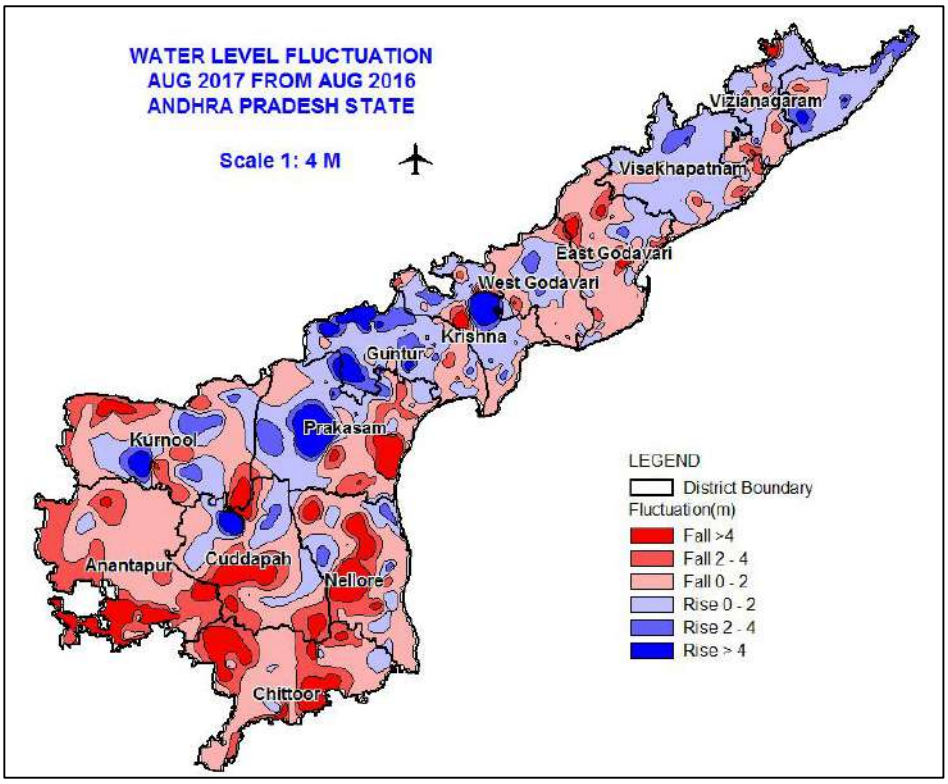


Fig. 7.11: Water Level Fluctuations (August 2016 from August 2015)

7.4.3 Water Level Fluctuations (November, 2017 from November, 2016)

The district-wise water level fluctuations from Nov 2016 to Nov 2017 are presented in **Annexure-XIV.** An analysis of 727 wells shows that water level rise is recorded in 59 % wells (429 nos) and 39% of wells (284 nos) have shown a fall in water level and 3% of wells (14 nos) have no rise or fall in water levels. Rise in water levels is mainly due to 16.7% more rainfall than last year same period in the state i.e., June to October, especially in Rayaseema region , Prakasam, Nellore ,receiving 24% to 58 % more than the same period last year. Spatial distribution water level fluctuations is presented in **Fig 7.12.**

The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in Krishna, Nellore and Visakhapatnam districts and 22.14 m in Prakasam districts. The minimum and maximum fall in water level fluctuations recorded is 0.01 m in Kadapa, East Godavari, Prakasam and Guntur districts and 20.2 m in Guntur district. In the state, more than 4 m rise in water levels is recorded 56 wells (8%) mainly in Rayalaseema district and East Godavari and West Godavari districts. Fall of more than 4 m is observed as small patches in Krishna, Anantapuramu district. Rise and fall from -2 m to +2 m is more dominant in the state. The dominant fluctuation range is 0-2 m.

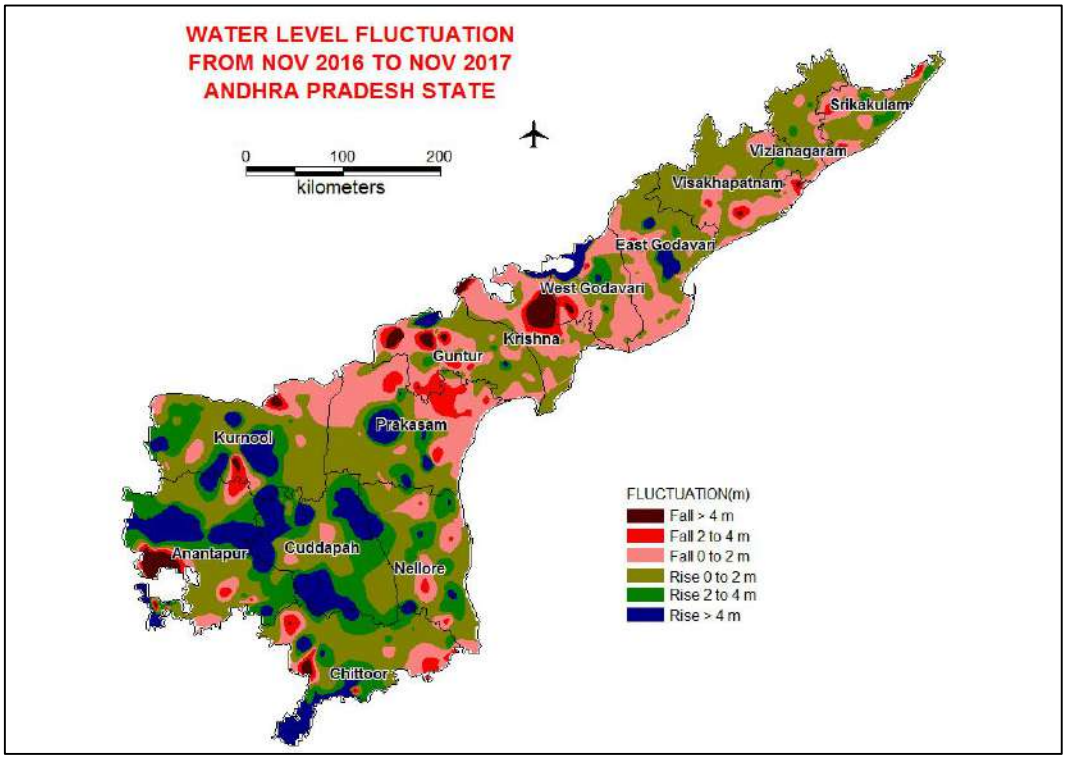


Fig. 7.12 : Water Level Fluctuations (November,2017 from November,2016)

7.4.4 Water Level Fluctuations (January-2018 from January-2017)

The district-wise water level fluctuations from Jan 2017 to Jan 2018 are presented in **Annexure-XV.** An analysis of 770 wells shows that water level rise is recorded in 61 % wells (466 nos) and 39% of wells (304 nos) have shown a fall in water level. Rise in water levels is mainly due to 18.4% more rainfall than last year same period in the state i.e., June to December, especially in Rayaseema region and Nellore. Spatial distribution water level fluctuations is given in **Fig 7.13.**

The minimum and maximum rise in water level fluctuations is recorded as 0.01 m occurring in all the districts of the state and 53.79 m in YSR Kadapa district. The minimum and maximum fall in water level fluctuations recorded is 0.01 m SPS Nellore district 31.1in Prakasam district respectively. In the state, more than 4 m rise in water levels is recorded 39 wells (8%) mainly in Rayalaseema districts and in SPS Nellore district. Fall of more than 4 m is observed in 17 wells (6%) in Prakasam district and as small patch in Guntur district. Fluctuation between -2 m to +2 m is more dominant in the state

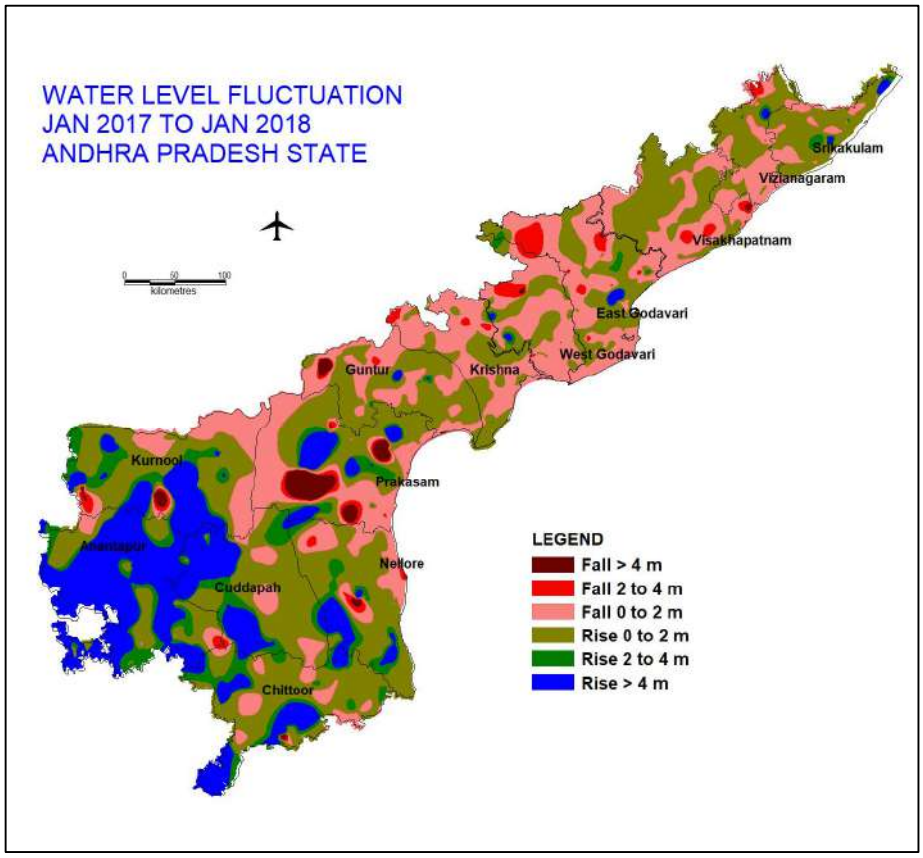


Fig. 7.13: Water Level Fluctuations (January, 2018 from January, 2017).

7.5 Decadal Water Level Fluctuations

7.5.1 Water Level Fluctuations (May 2017 from Decadal mean of May(2007-16))

Water level fluctuation data of May 2017 vs decadal mean (2007-2016) is presented in **Annexure - XVI.** An analysis of data of 751 wells shows that water level rise is recorded in 25.0% wells (185 no of wells), water level fall is recorded in 75.0% wells (562 no of wells). Fluctuation of water levels in May 2017 vs decadal mean(2007-2016) is depicted in **Fig. 7.15**.

Area-wise, 41% of the state experienced water levels rise compared with the decadal mean. Out of 185 wells, water level rise of less than 2 m is recorded in 21% wells, in the range of 2-4 m in 2% wells and rise of more than 4 m is recorded in 2% wells. About 41% of area in the state shows rise in water level compared with the decadal mean of May. Rise of Water level more than 4 m is observed 12 wells in anantapuramu, Chittoor, Kurnool, Prakasam and small patches in Visakhapatnam and Vizianagaram district.

Area-wise, 59% of the state experienced water levels fall compared with the decadal mean. Out of the 562 wells that have registered fall in water levels, 53% have

recorded less than 2 m fall, 14% in the range of 2-4 m and 8% wells registered water level fall of more than 4 m.. Area-wise, 59% of the area in the state shown fall in water levels compared with decadal mean of May (2007-16). Fall of more than 4 m is mainly observed in Kurnool, Anantapur, Kadapa, Nellore and Prakasam districts.

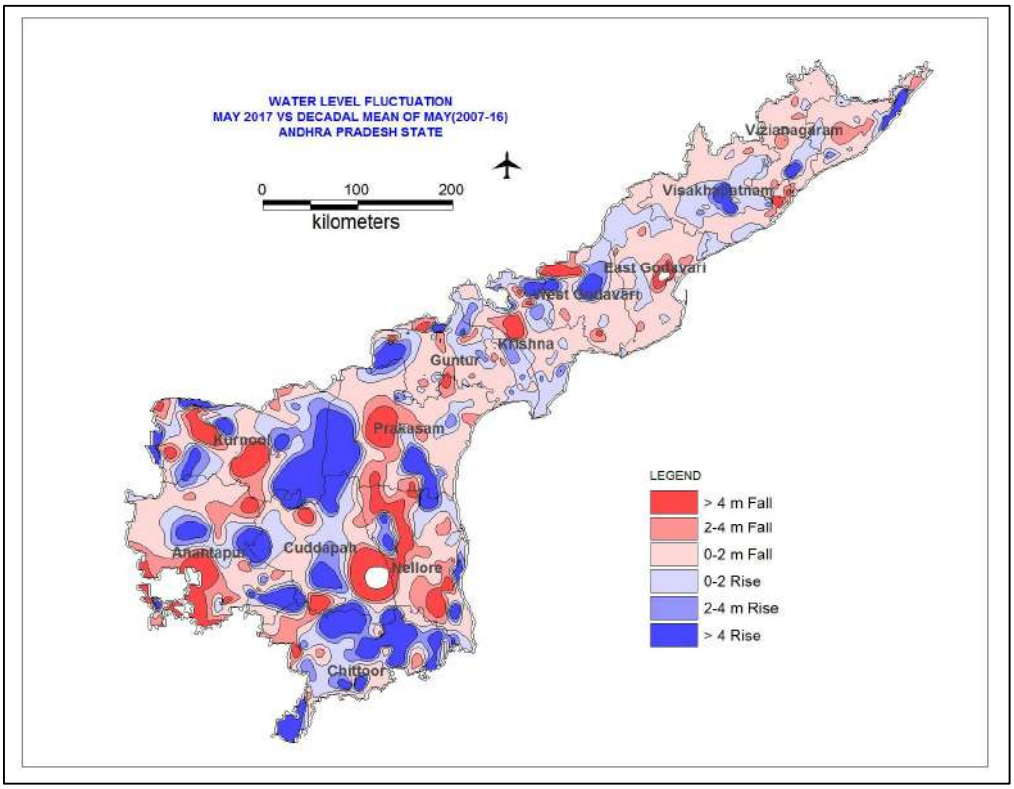


Fig.7.14: Water Level Fluctuations (May, 2016 from Decadal Mean of May (2006-2015))

7.5.2 Water Level Fluctuations (August,2017 from Decadal Mean of August (2007-2016))

Water level fluctuation of August, 2017 from Decadal mean of August (2007-2016) is presented in **Annexure-XVII. S**patial distribution of fluctuation is presented in **Fig 7.15**. An analysis of 737 wells data shows that rise in water levels is observed in 296 wells (40% of wells) and fall in 437 wells (59% of wells) . Perusal of the map shows a general fall in water levels in major part of the state. The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in Srikakulam and 19.7m in Guntur districts. The minimum and maximum fall in water level fluctuations is recorded in 0.01 m West Godavari district and 27.3 m in Prakasam district.In the state 40% of the wells shown a rise in water levels and rise of more than 4 m is observed as small patches in Prakasam, Guntur and East Godavari districts. Perusal of the map shows that fall is observed in 59% of the wells and more than 4

m fall is observed in Prakasam, Anantapur, Kurnool and small patch in East and West Godavari districts.

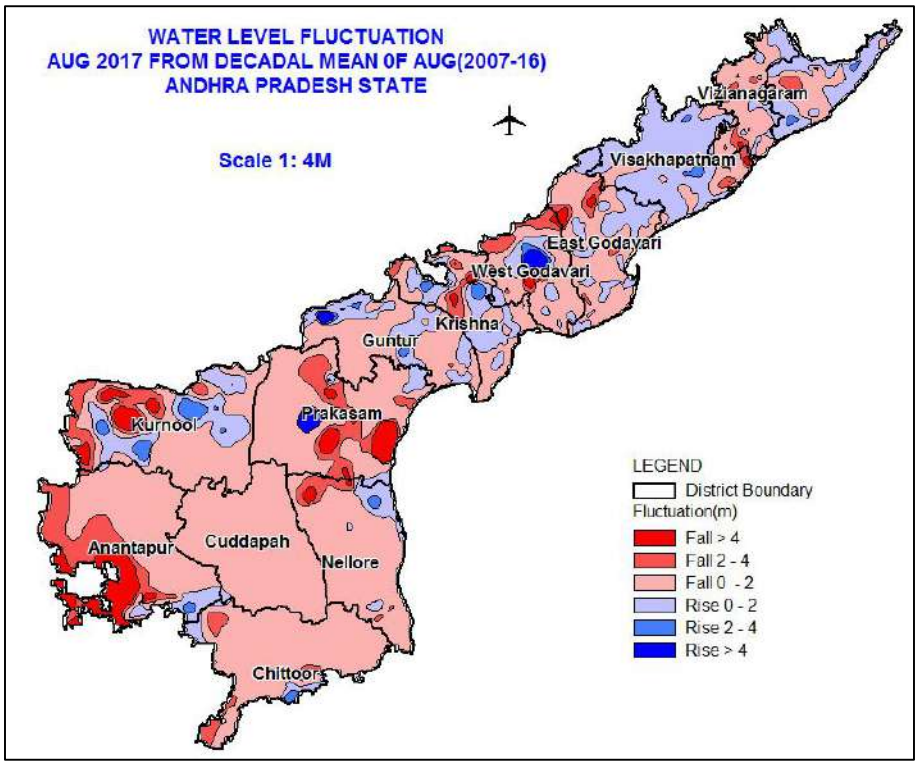


Fig. 7.15: Water Level Fluctuations, August , 2017 from Decadal Mean of August (2007-2016)

7.5.3 Water Level Fluctuation- Nov, 2017 from Decadal Mean of Nov (2007-2016)

District-wise water level fluctuations from decadal mean of Nov(2007-06) to Nov 2017 is presented in **Annexure-XVIII. S**patial distribution of fluctuations as **Fig 7.16**. An analysis of 744 wells data shows that rise in water levels is observed in 352 wells (47%) and fall in 392 wells (53%)

The minimum and maximum rise in water level fluctuations ranges from 0.01 m to 29.3m in Guntur district. The minimum and maximum fall in water level fluctuations ranges from 0.01 m to 22.96 in Guntur district. In the state, more than 4 m rise is observed in 26 wells (3%) in Kadapa, Chittoor and East Godavari and West Godavari districts. Fall of more than 4 m is observed in 32 wells (4%) in Anantapur and Krisha districts. The dominant range is between -2 m to +2 m covering 75% of the wells in the state..

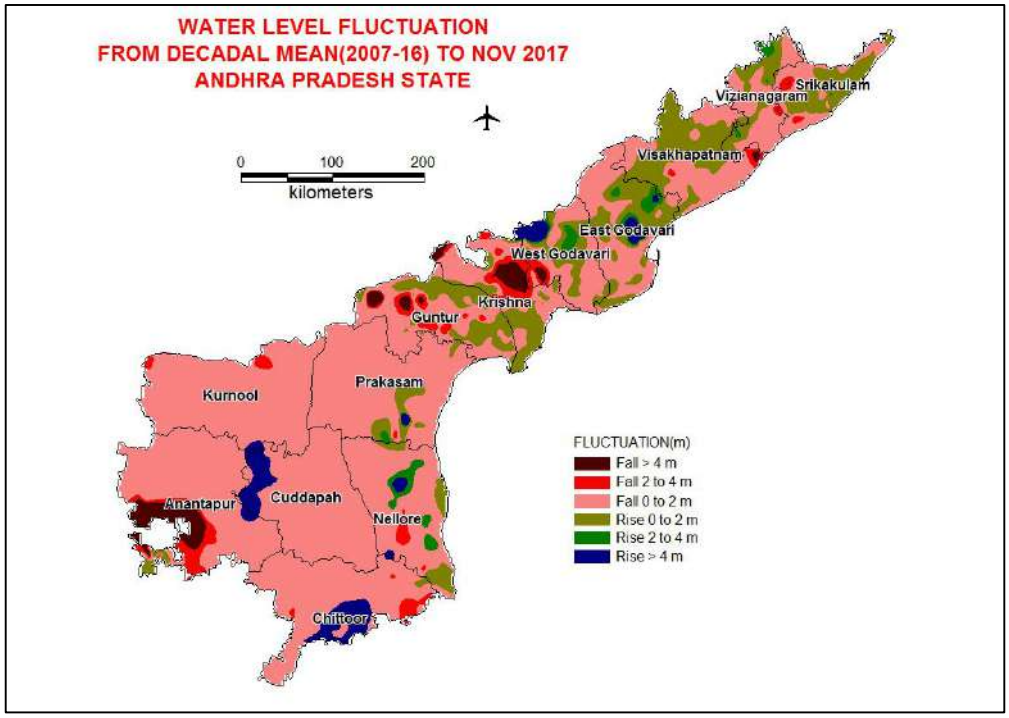


Fig. 7.16: Water Level Fluctuations (Nov, 2017 from Decadal Mean of Nov (2007-2016))

7.5.4 Water Level Fluctuation- January, 2018 from Decadal Mean of Jan (2008-17)

. District-wise water level fluctuations from decadal mean of Jan (2008-17) to Jan 2018 is presented in **Annexure-XIX.** An analysis of 788 wells shows that water level rise is recorded in 45 % wells (358 nos) and fall in water levels in 55% of wells (430 nos). Spatial distribution water level fluctuations is presented in **Fig 7.17.**

The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in occurring in all the districts of the state and 53.79 m in YSR Kadapa district respectively. The minimum and maximum fall in water level fluctuations recorded is 0.02 m to 34.9 m in Prakasam district. In the state, more than 4 m rise in water levels is recorded 16 wells (4%) mainly in Kurnool, Kadapa and Chittoor districts and small patc in Anantapuramu district. . Fall of more than 4 m is observed in 40 wells (9%) in Prakasam district and as small patch in Krishna district. Fluctuation between -2 m to +2 m is more dominant in the state.

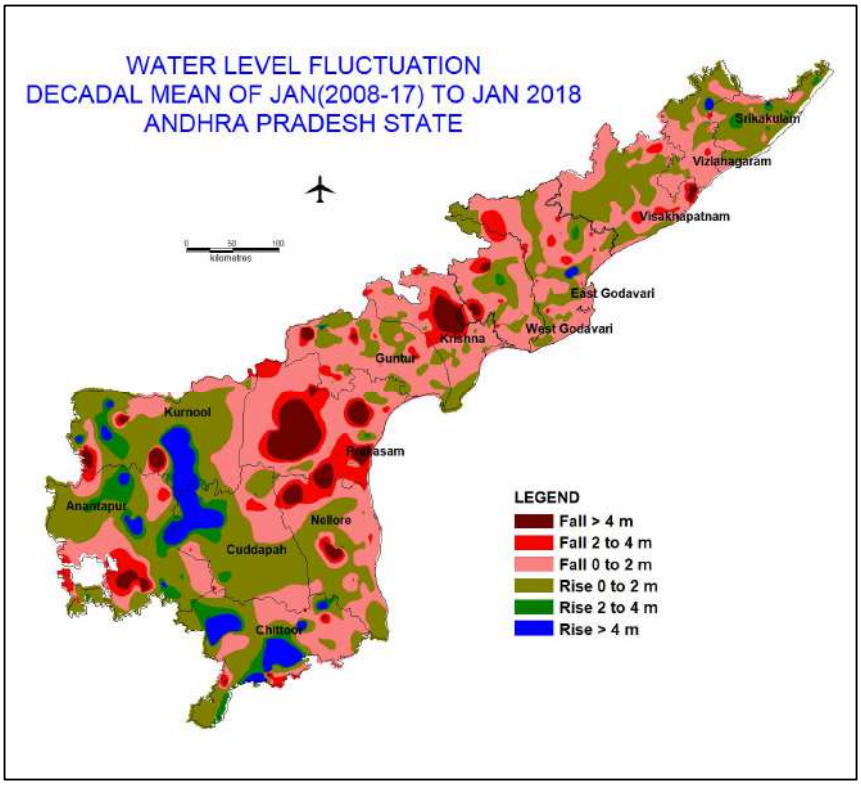


Fig. 7.17: Water Level Fluctuations (Jan, 2018 from **Decadal Mean of Jan (2008-17))**

7.6 Aquifer wise water levels

Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in all the formations except in Intrusives. Deepest water levels are observed alluvium, Limestone and BGC. During post-monsoon season, shallowest water leves are observd in all formations except in Intrusives and Laterites. Deepest water levels are observed in Gniess, Granite, Limestone, Quartz and Sandstone. Aquifer wise water level scenario is presented in **Table-7.3.**

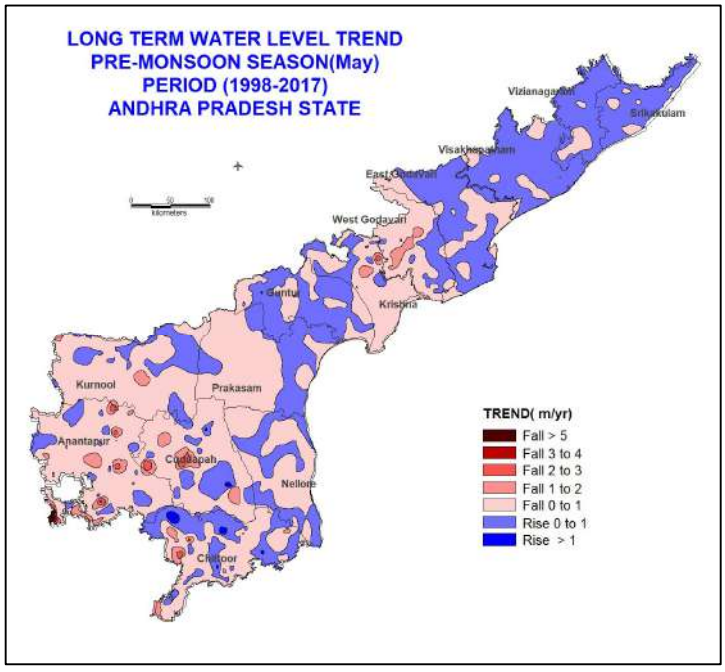
Table-7.3: Aquifer wise Minimum, Maximum and Average values of water levels, Andhra Pradesh State.

Principle Aquifer	Pre-monsoon May 2017			Post-monsoon Nov 2017		
	Minimum	Maximum	Average	Minimum	Maximum	Average
ALLUVIUM	0.27	35.48	2.64	0.28	36.18	4.16
BRANDED GNIESSIC COMPLEX	-0.18	27.46	4.12	1.72	41.73	8.39
CHANROCKITE	0.41	14.90	3.31	0.48	14.90	5.57
GNIESS	0.23	30.72	3.98	0.95	49.30	7.12
GRANITE	-0.30	20.99	5.74	0.90	46.00	10.35
INTRUSIVES	6.38	6.38	6.38	12.82	12.82	12.82
KHONDALITE	0.66	28.80	3.44	1.40	28.25	6.61
LIMESTONE	-0.28	39.50	6.79	0.55	99.50	12.72

Principle Aquifer	Pre-monsoon May 2017	Post-monsoon Nov 2017	Principle Aquifer	Pre-monsoon May 2017	Post-monsoon Nov 2017	Principle Aquifer
LATRITE	0.36	9.50	3.75	4.42	9.65	6.39
QUARTZITE	0.96	10.80	4.32	0.95	39.10	10.07
SCHIST	0.48	12.50	5.52	1.57	17.00	8.42
SHALES	-0.18	21.23	5.14	1.07	29.30	9.38
SANDSTONE	0.90	18.05	4.89	2.02	84.40	10.62

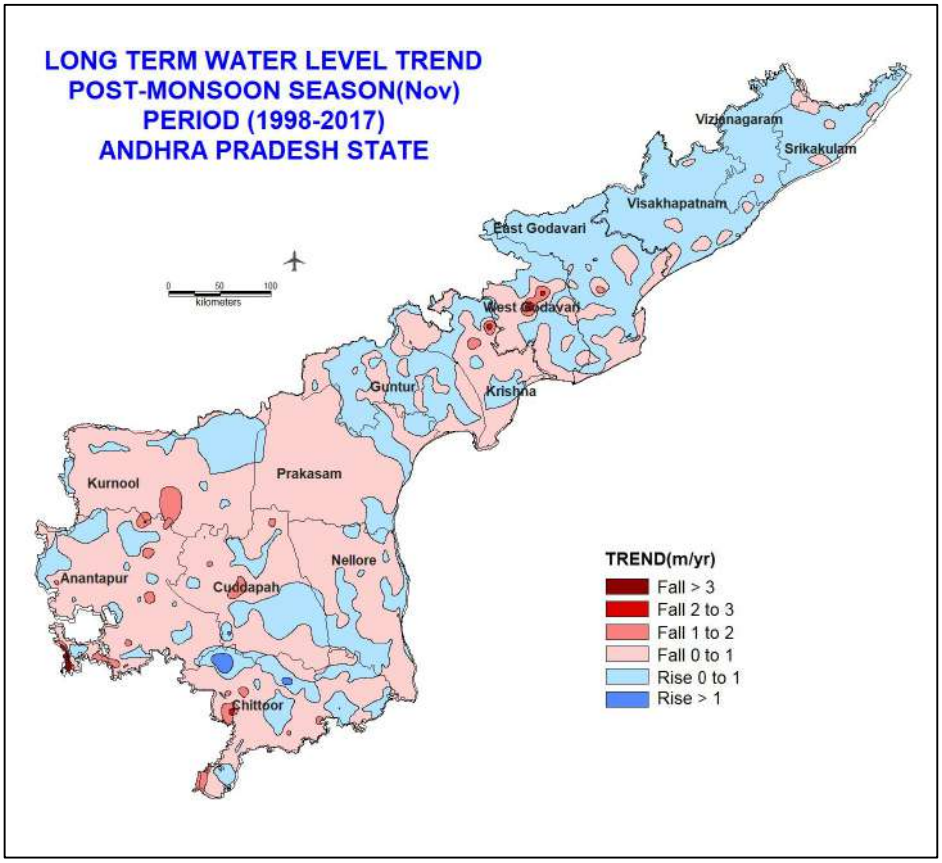
7.7 Long-term Water Level trends:

7.7.1 Pre-monsoon trend map: It is inferred from the pre-monsoon water level trend map that the falling trend in water level of 0-5 m/yr is observed in 60% of the area and rising trend of 0-3 m / yr in water level is observd in 40% of the area in the state. Falling trend is recorded at 481 locations and 358 locations have recored rising trend during May. Falling trend of 0 to 1 m/yr is more prevalent in rayalaseema region and Prakasam, Nellore and Krishna and West Godavari district. The falling trend of 1 to 2 m/yr is observed in Kurnool , Kadapa, anantapur, Chittoor , Krishna and West Godavari districts as small patches. Falling trend of more than 2 m/yr is restricted to few locatins in all the Rayalaseema districts. Rising trend of 0 to 1 m/yr is predominant in all the coastal distrits and parts of Prakasam, Nellore, Kadapa, Chittor and Kurnool districts. Falling trend ranges from 0.001 m/yr to 5.03 m/yr. , while rising trend ranges from 0.001 to 1.53 m/yr. More than 1 m / yr rise is seen in Guntur, Kadapa and Chittoor districts. The district-wise trend analysis is given in **Table 7.4**.



7.18 Long term water level trend – Pre-monsoon period (1998-2017)

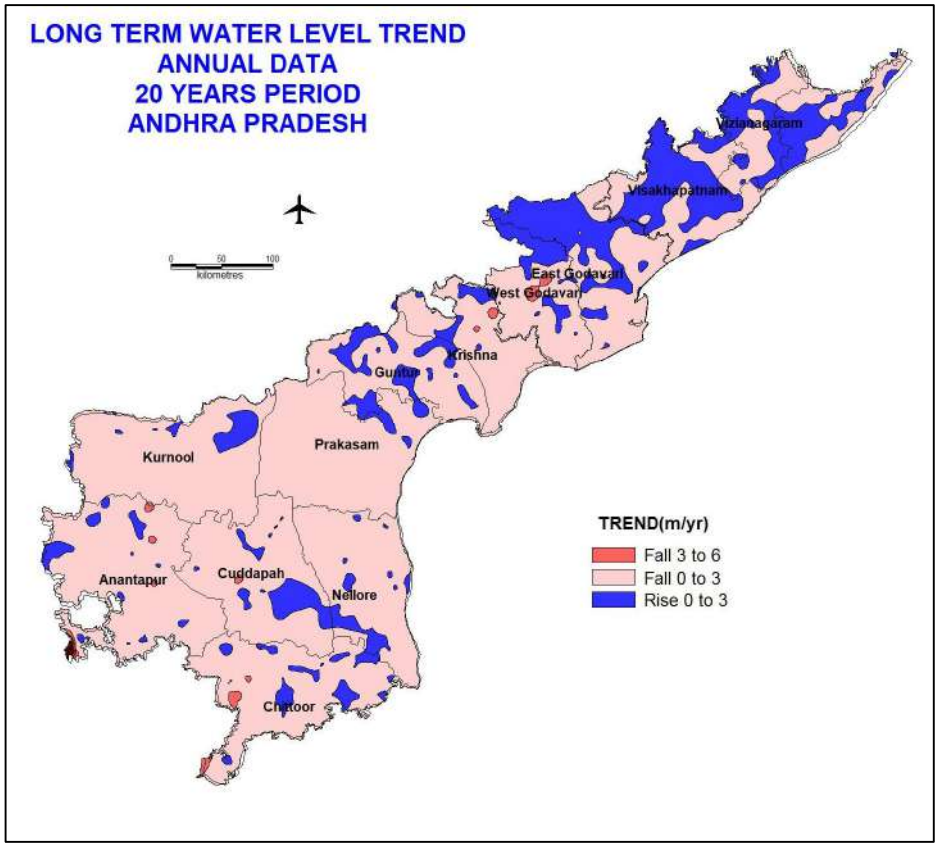
7.7.2 Post-monsoon trend map: It is inferred from the post-monsoon water level trend map that the falling trend in water level of 0-5 m/yr is observed in 58% of the area and rising trend of 0-3 m / yr in water level is observed in 42% of the area in the state. Falling trend is recorded at 466 locations and 403 locations have recored rising trend. Falling trend of 0 to 1 m/yr is more prevalent in Rayalaseema region and Prakasam, Nellore, Krishna and West Godavari district. The falling trend of 1 to 2 m/yr is observed in Kurnool , Kadapa, Chittoor , Krishna and West Godavari districts as small patcches. Falling trend of more than 2 m/yr is restricted to few locatins in all the Anantapur, Chittoor, West Godavari and Krishna districts. Rising trend of 0 to 1 m/yr is predominant in all the coastal districts and parts of Prakasam, Nellore, Kadapa, Chittor and Kurnool districts. Falling trend ranges from 0.001 m/yr to 0.053 m/yr, while rising trend ranges from 0.001 to 2.67 m/yr. More than 1 m / yr rise is seen assmall patch in Chittoor district. The district-wise trend analysis with salietnt features is given in **Table 7.3**.



7.19 Long term water level trend Post-monsoon period (1998-2017)

7.7.3 Annual trend map: It is inferred from the annual water level (20 years) trend map that the falling trend in water level in the state is observed in 81% of the area and rising trend in the range 0 to 3 m/yr is observed in 18% of the area. The predominant range is

falling trend in the range of 0-3 m / yr which is observed in Rayalaseema region except few isolated patches , where rising trend is noticed, and parts of Prakasam, West and East Godavari, Krishna districts and also few patches in the north coastal districts. The rise in water level trend of 0 to 3.0 m/yr is prevalent in Srikakulam, Vizianagaram, Visakhapatnam districts and also in some inland areas parts of East Godavari and West Godavari, Guntur, Chittoor and SPS Nellore districts.**(Fig 7.18)**



7.20 Long term water level trend - Annual (1998-2017)

Fall and rise in long term water levels for 20 years period are distributed area-wise are as follows:

Criteria	Fall	Rise	Fall in % of area	Rise in % of area
	Area (sq.km.)		(%)	
Pre-monsoon	97600	65360	60%	40%
Post-monsoon	94370	68590	58%	42%
Annual	132000	30960	81%	19%

TABLE 7.4 ANALYSIS OF TREND VALUES OF WATER LEVELS (1998-2017) IN ANDHRA PRADESH

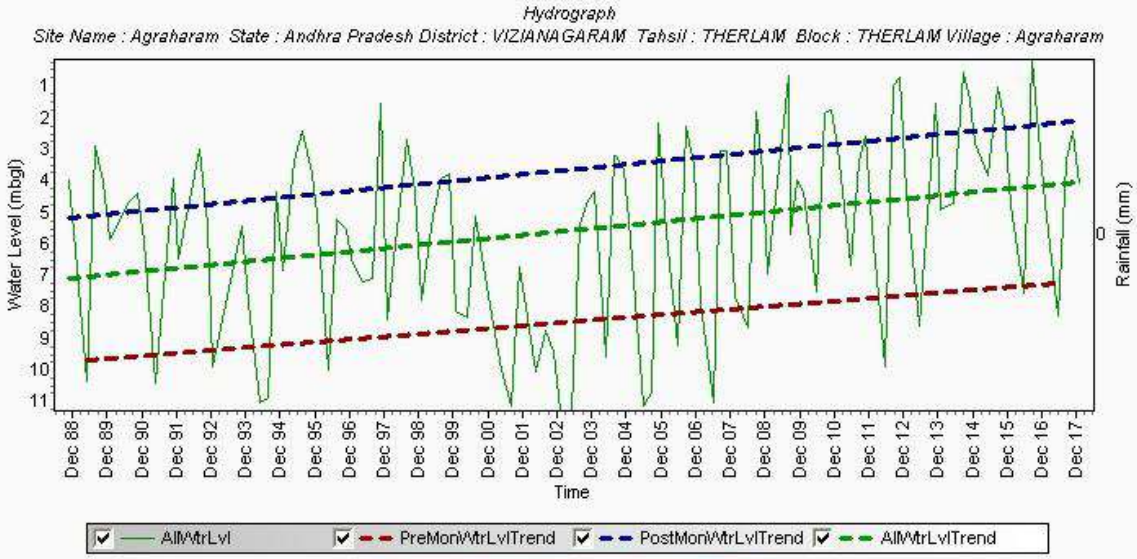
	Pre-monsoon (May)						Post-monsoon (Nov)					
	Falling trend in			Rising trend			Falling trend in			Rising trend		
DISTRICT	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**
ANANTAPUR	100	-5.033	-0.009	30	0.007	0.830	94	-5.5345	-0.0007	34	0.003	0.796
CHITTOOR	47	-2.641	-0.020	48	0.005	1.532	64	-2.3645	-0.0006	36	0.008	1.840
CUDDAPAH	57	-3.196	-0.002	18	0.041	1.397	48	-1.5780	-0.0148	27	0.004	2.668
EAST GODAVARI	27	-0.583	-0.004	36	0.006	0.261	27	-1.4602	-0.0007	50	0.006	1.089
GUNTUR	35	-0.631	-0.009	41	0.004	1.006	35	-0.6096	-0.0105	53	0.001	0.697
KRISHNA	40	-4.209	-0.001	19	0.001	0.358	32	-2.3709	-0.0006	26	0.001	0.666
KURNOOL	56	-3.043	-0.003	27	0.022	0.656	43	-1.3092	-0.0033	20	0.006	0.196
NELLORE	33	-1.006	-0.006	23	0.008	0.304	40	-0.9663	-0.0034	29	0.004	0.256
PRAKASAM	26	-0.381	-0.003	14	0.001	0.267	35	-0.9907	-0.0063	7	0.002	0.197
SRIKAKULAM	7	-0.175	-0.040	26	0.005	0.418	7	-0.2230	-0.0526	25	0.004	0.282
VISAKHAPATNAM	11	-0.244	-0.001	33	0.014	0.317	9	-0.3590	-0.0121	39	0.015	0.425
VIZIANAGARAM	6	-0.091	-0.015	20	0.009	0.273	1	-0.0081	-0.0081	25	0.001	0.173
WEST GODAVARI	36	-1.968	-0.001	23	0.012	0.611	31	-2.5544	-0.0069	32	0.003	0.954
TOTAL	**481**	**-5.033**	**-0.001**	**358**	**0.001**	**1.532**	**466**	**-0.053**	**-0.001**	**403**	**0.001**	**2.668**

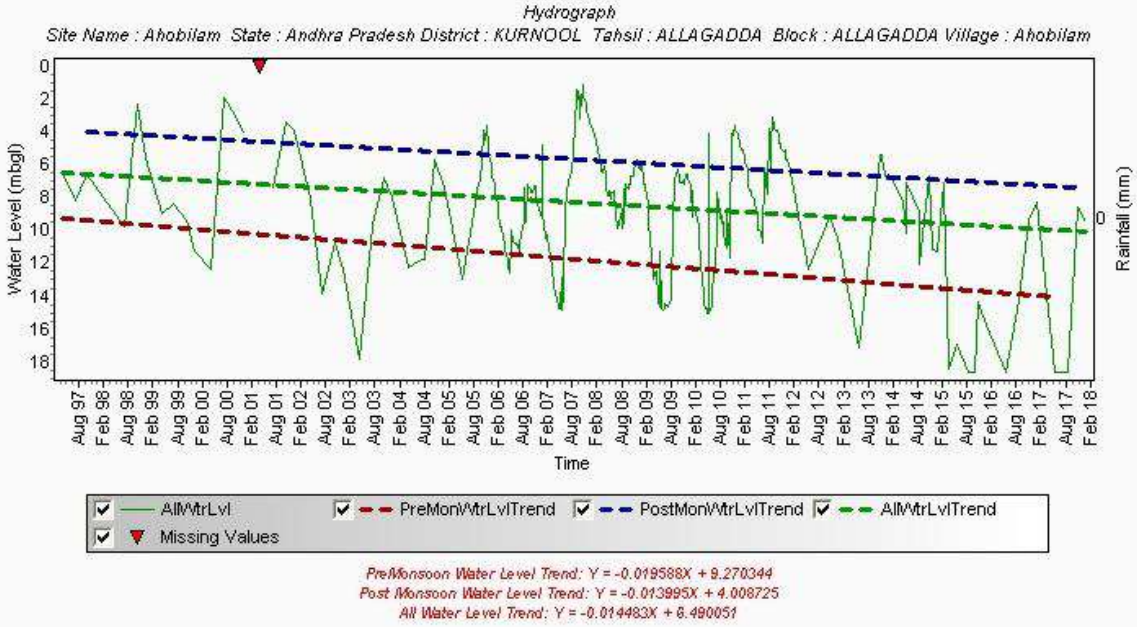
7.8 Hydrographs of water levels

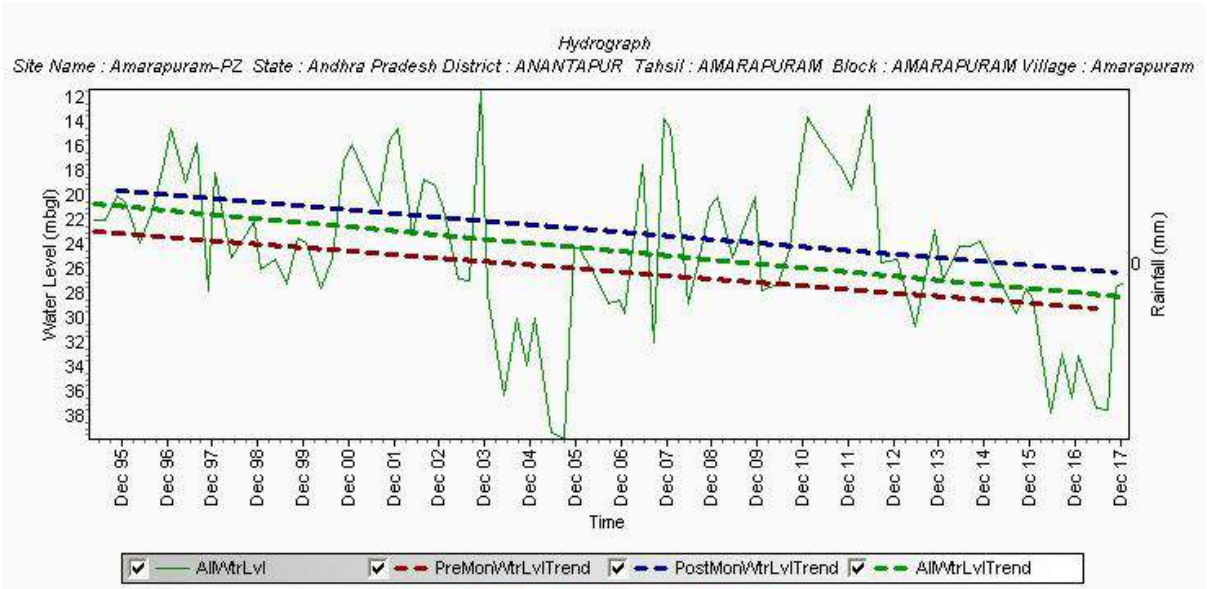
Total 26 hydrographs are generated (2 from each district) (**Fig. 7.21**). Out of 26, 7 wells show rising trends in both seasons, 11 shows falling trends in both season and rest shows mix trends (**Table-7.5**).

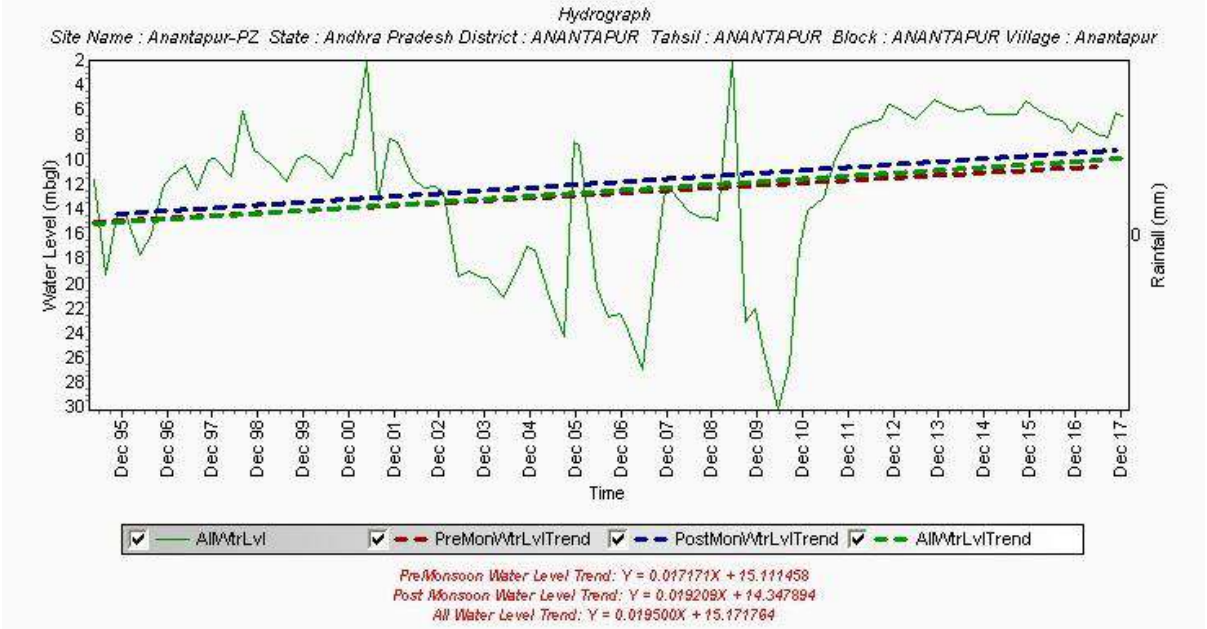
Table-7.5: Representative Hydrographs showing rising and falling trends in Andhra Pradesh State.

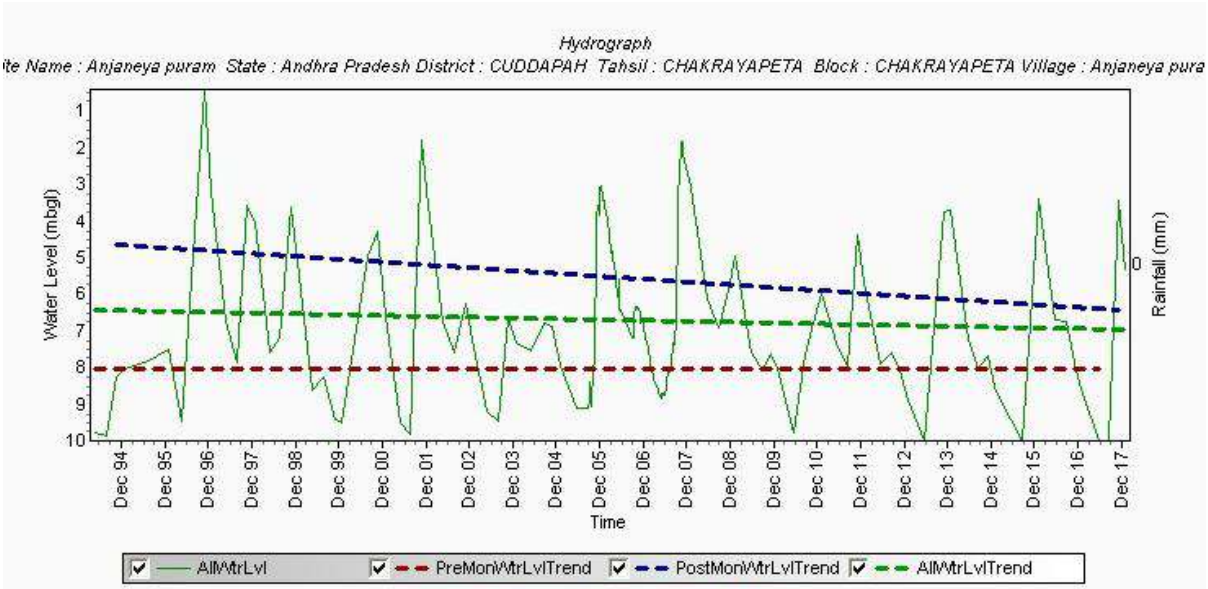
S. No.	Location	District	Pre (m/yr)		Post (m/yr)	
			Rise	Fall	Rise	Fall
1	Amarapuram	Anantapur		0.2808		0.294
2	Anatapur	Anantapur	0.206		0.2304	
3	Damalcheruvu	Chittoor	0.026			0.018
4	Battuvaripalli	Chittoor	0.037			0.0003
5	Muddireddipalli	Cuddapah		0.105		0.204
6	Anjaneyapuram	Cuddapah		0.00012		0.756
7	Jaggampet	East Godavari	0.15		0.054	
8	Gollaprolu	East Godavari	0.0204			0.0018
9	Ipur	Guntur		0.026		0.043
10	Guntur	Guntur	0.015			0.014
11	Nuziveedu	Krishna	0.094		0.028	
12	Gudivada	Krishna		0.001		0.0063
13	Gonegandla	Kurnool	0.156		0.048	
14	Ahobilam	Kurnool		0.2352		0.1668
15	Kadanothola	Nellore		0.076	0.0015	
16	Bata	Nellore		0.0384		0.09
17	Chirala	Prakasam		0.012		0.006
18	Chandalur	Prakasam		0.1104	0.0117	
19	Ichapuram	Srikakulam		0.008	0.039	
20	Barua	Srikakulam	0.075		0.118	
21	Narsipattanam	Vishakhapattanam	0.003			0.003
22	Araku	Vishakhapattanam		0.033		0.021
23	Agraharam	Vizianagaram	0.085		0.103	
24	Garbham	Vizianagaram		0.014		0.007
25	Kovvur	West Godavari	0.032		0.032	
26	Eluru	West Godavari		0.984		0.0864

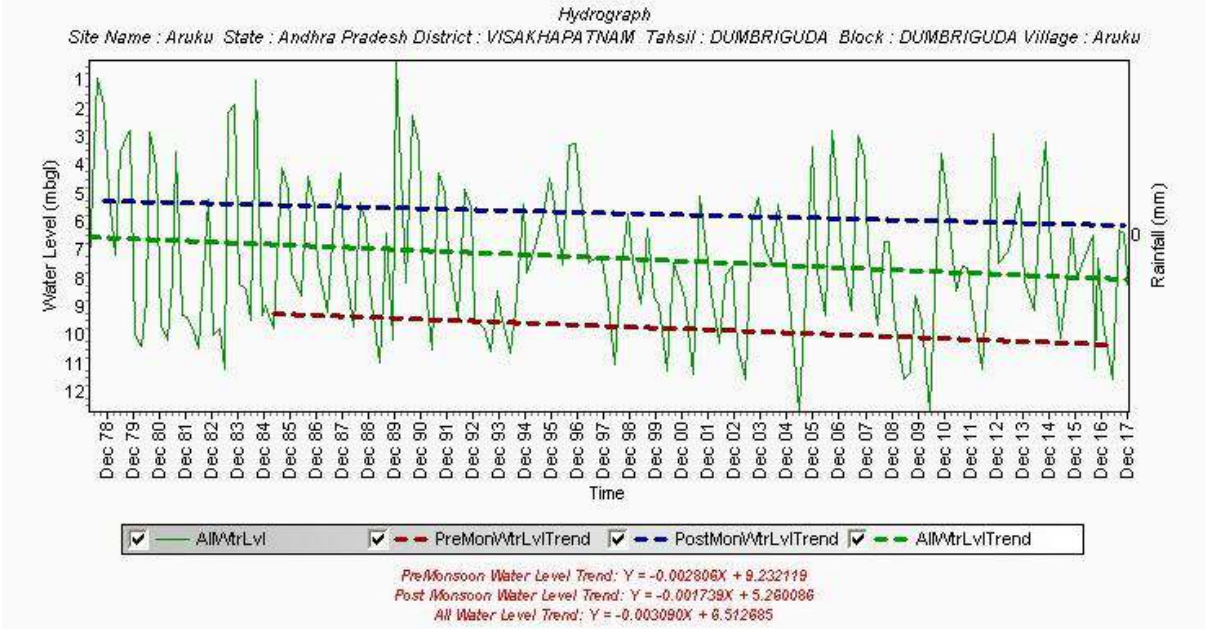

Hydrograph
Site Name : Agraharam State : Andhra Pradesh District : VIZIANAGARAM Tahsil : THERLAM Block : THERLAM Village : Agraharam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.007163X + 9.699580
Post Monsoon Water Level Trend: Y = 0.008661X + 5.188005
All Water Level Trend: Y = 0.008835X + 7.118808

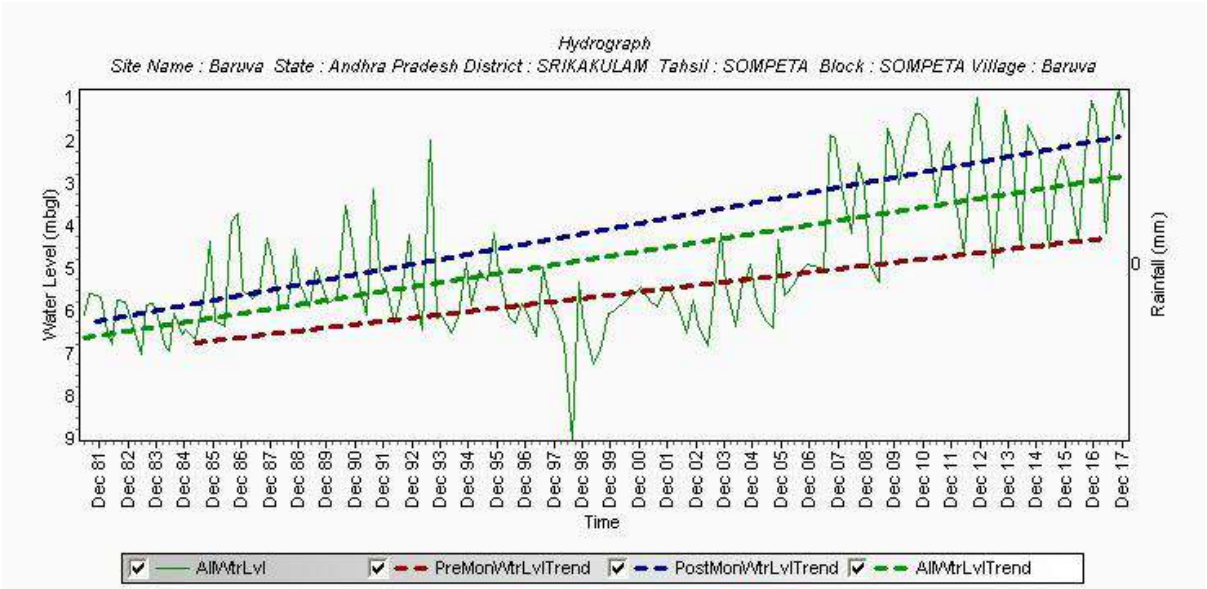

Hydrograph
Site Name : Ahobilam State : Andhra Pradesh District : KURNOOL Tahsil : ALLAGADDA Block : ALLAGADDA Village : Ahobilam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.019588X + 9.270344
Post Monsoon Water Level Trend: Y = -0.013995X + 4.008725
All Water Level Trend: Y = -0.014483X + 6.490051

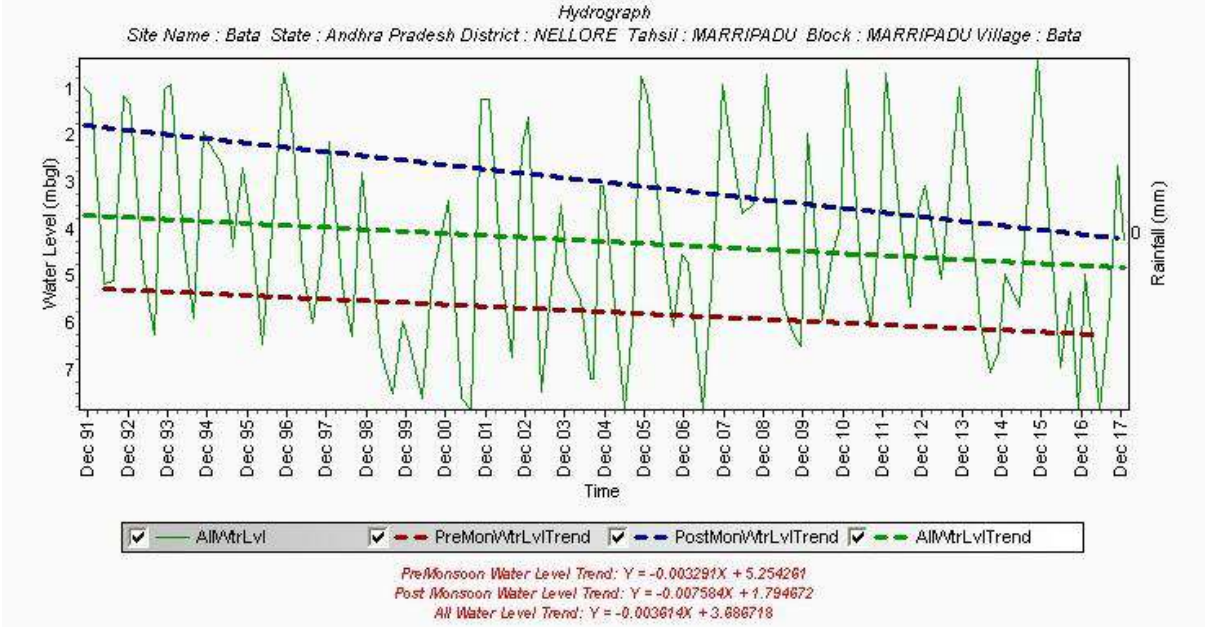

Hydrograph
Site Name : Amarapuram-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : AMARAPURAM Block : AMARAPURAM Village : Amarapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.023469X + 22.926898
Post Monsoon Water Level Trend: Y = -0.024558X + 19.654120
All Water Level Trend: Y = -0.028120X + 20.642787

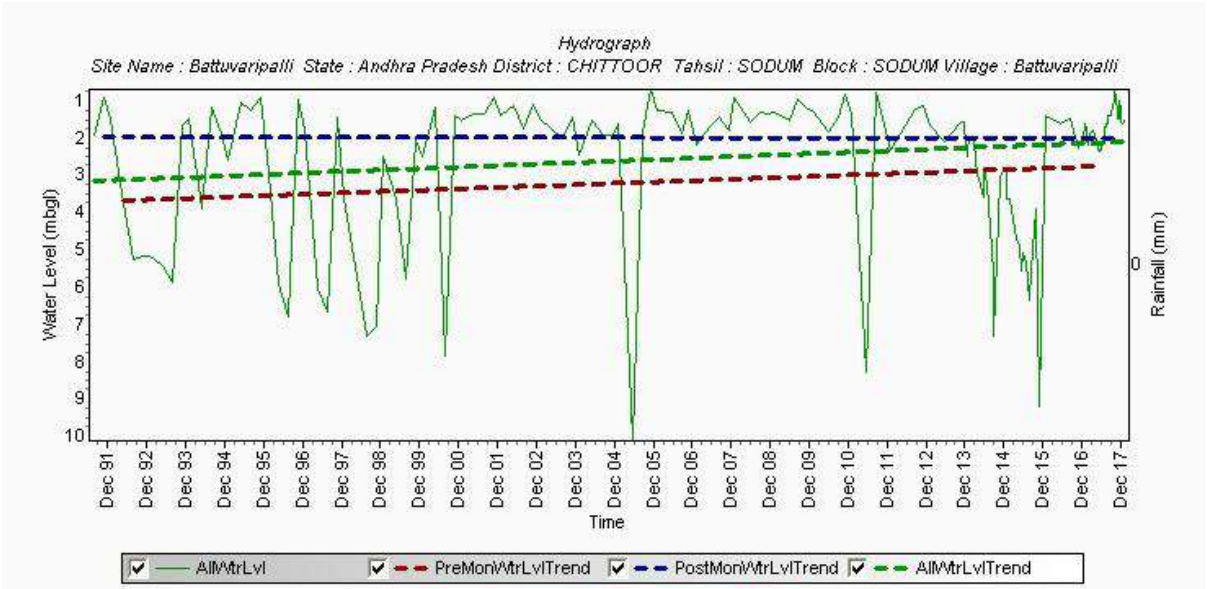

Hydrograph
Site Name : Anantapur-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : ANANTAPUR Block : ANANTAPUR Village : Anantapur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.017171X + 15.111458
Post Monsoon Water Level Trend: Y = 0.019209X + 14.347894
All Water Level Trend: Y = 0.019500X + 15.171764

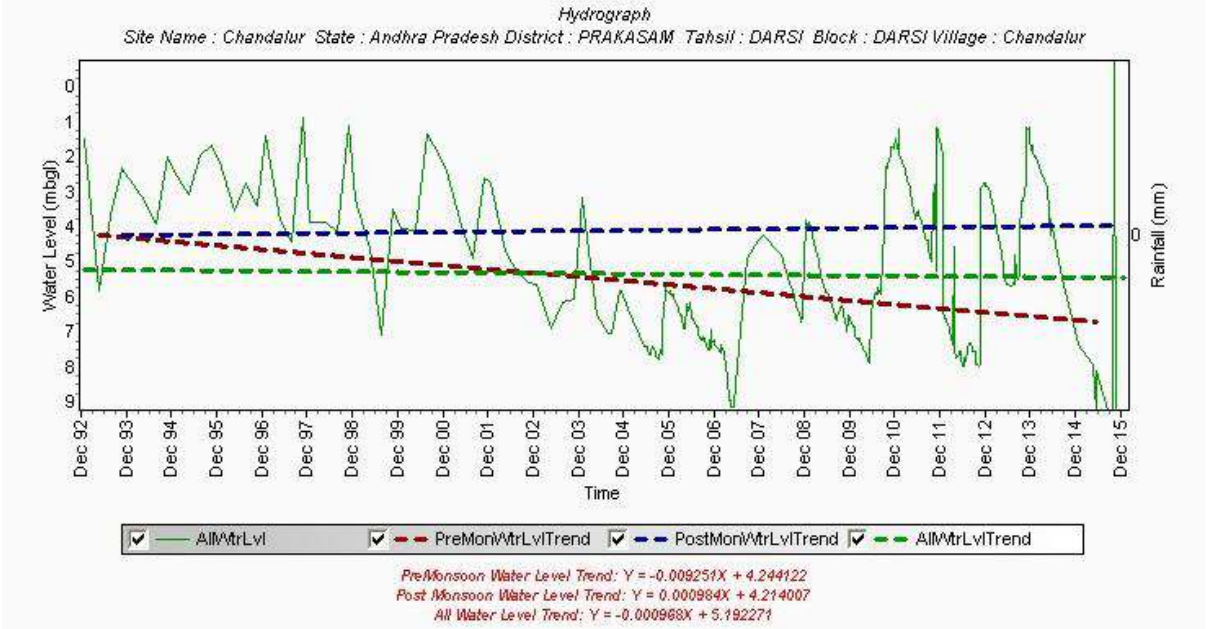

Hydrograph
te Name : Anjaneya puram State : Andhra Pradesh District : CUDDAPAH Tahsil : CHAKRAYAPETA Block : CHAKRAYAPETA Village : Anjaneya pura
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000013X + 8.034047
Post Monsoon Water Level Trend: Y = -0.006369X + 4.636904
All Water Level Trend: Y = -0.001892X + 6.430371

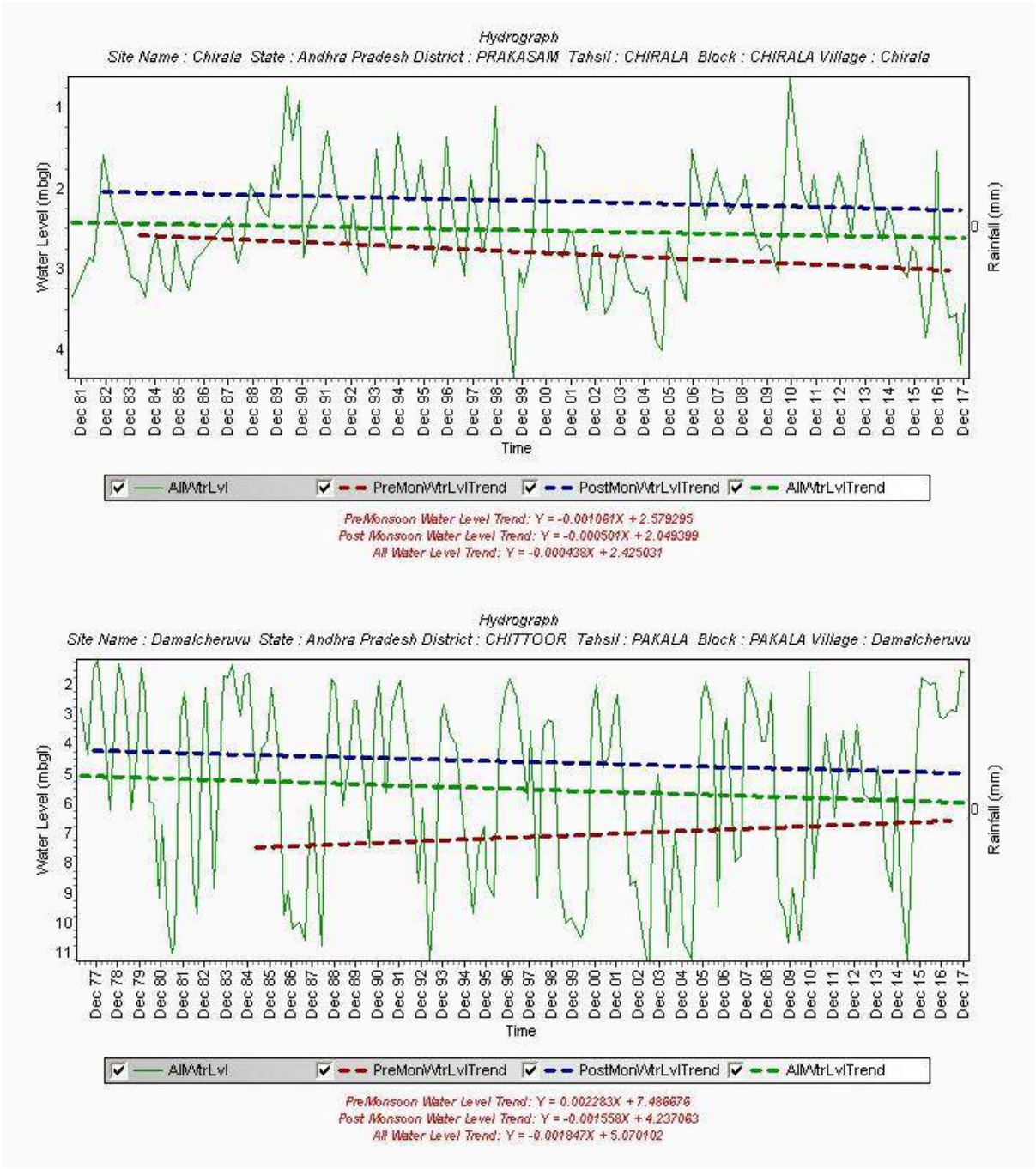

Hydrograph
Site Name : Aruku State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : DUMBRIGUDA Block : DUMBRIGUDA Village : Aruku
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002806X + 9.232119
Post Monsoon Water Level Trend: Y = -0.001739X + 5.260086
All Water Level Trend: Y = -0.003090X + 6.512685

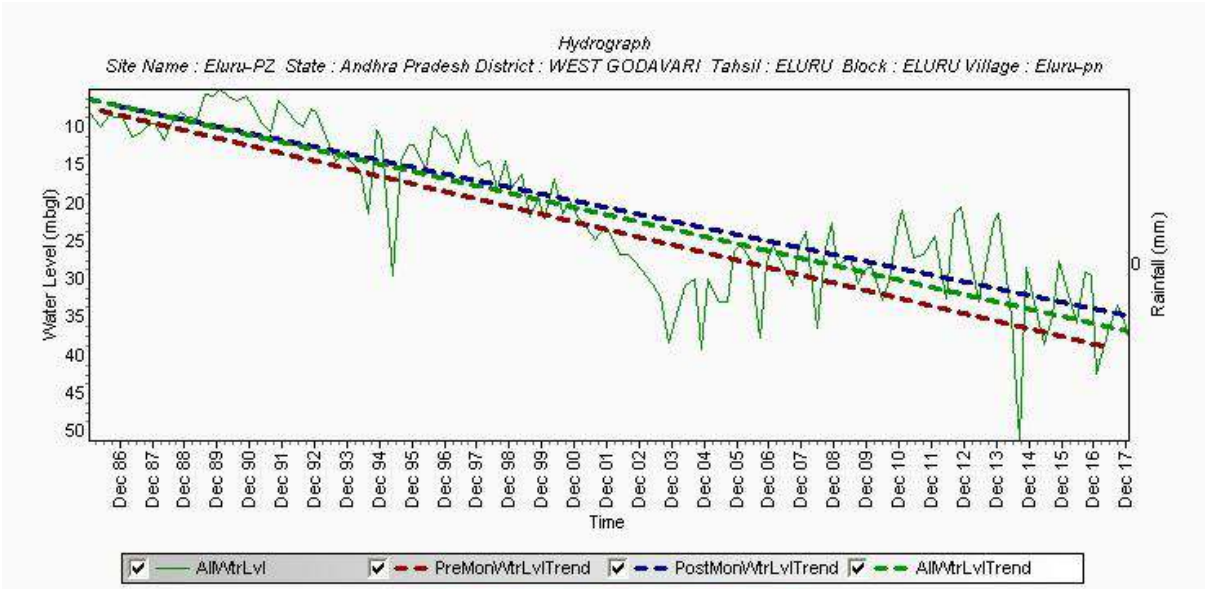

Hydrograph
Site Name : Baruva State : Andhra Pradesh District : SRIKAKULAM Tahsil : SOMPETA Block : SOMPETA Village : Baruva
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.006330X + 6.731288
Post Monsoon Water Level Trend: Y = 0.009949X + 6.250555
All Water Level Trend: Y = 0.008688X + 6.629764

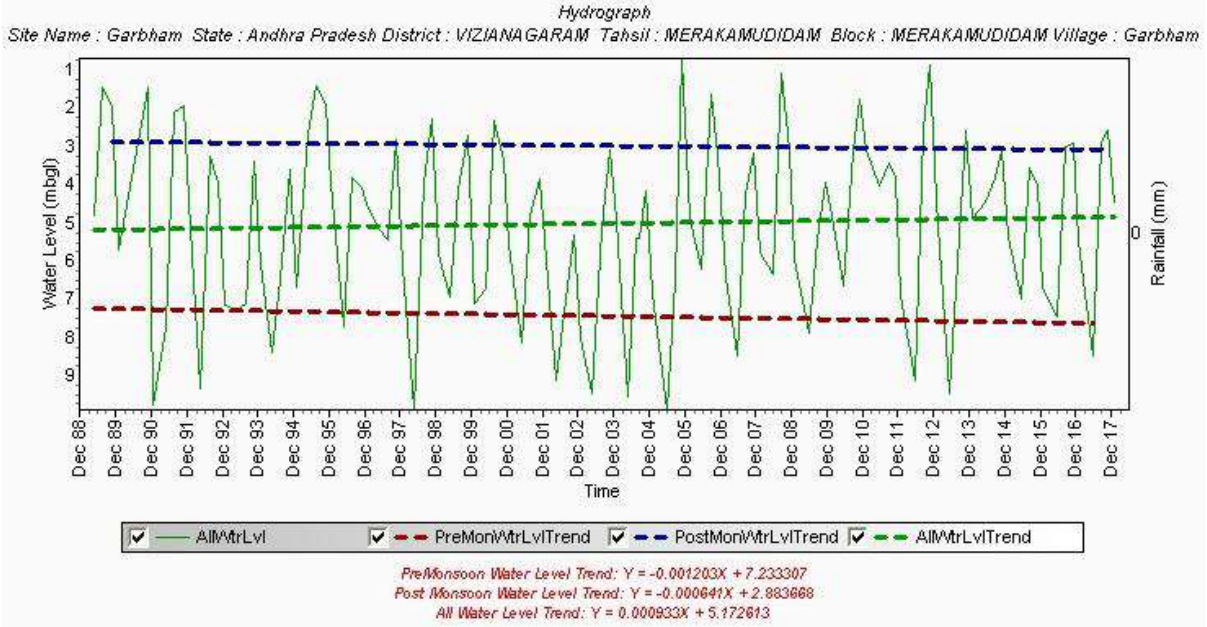

Hydrograph
Site Name : Bata State : Andhra Pradesh District : NELLORE Tahsil : MARRIPADU Block : MARRIPADU Village : Bata
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.003291X + 5.254261
Post Monsoon Water Level Trend: Y = -0.007584X + 1.794672
All Water Level Trend: Y = -0.003614X + 3.686718

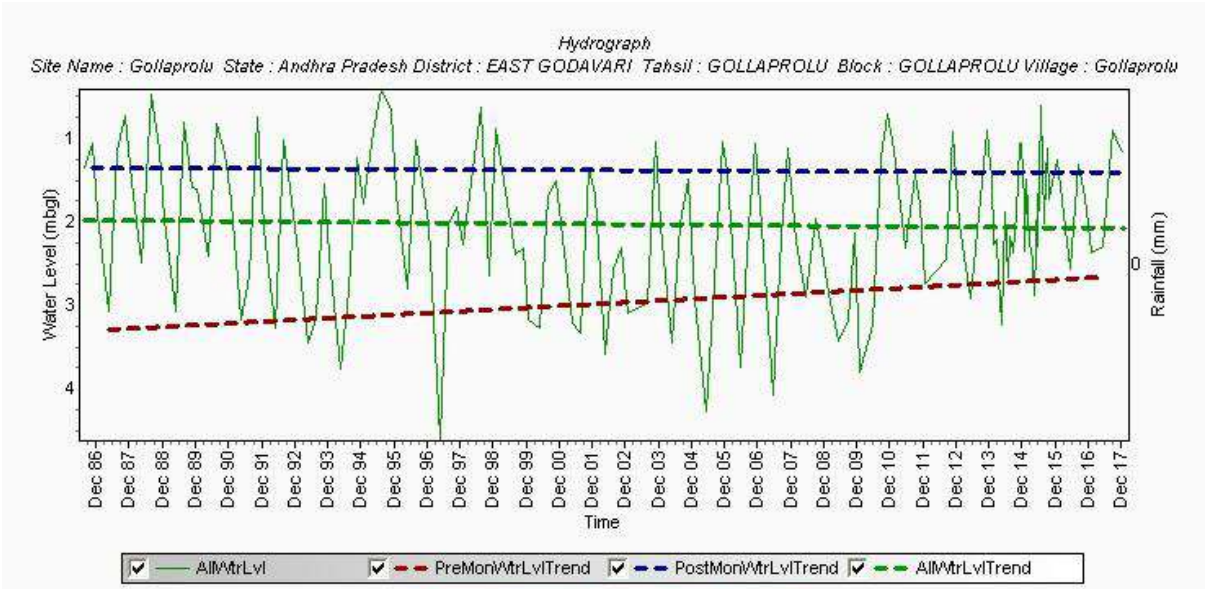

Hydrograph
Site Name : Battuvaripalli State : Andhra Pradesh District : CHITTOOR Tahsil : SODUM Block : SODUM Village : Battuvaripalli
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.003103X + 3.696795
Post Monsoon Water Level Trend: Y = -0.000037X + 1.981739
All Water Level Trend: Y = 0.003326X + 3.173648

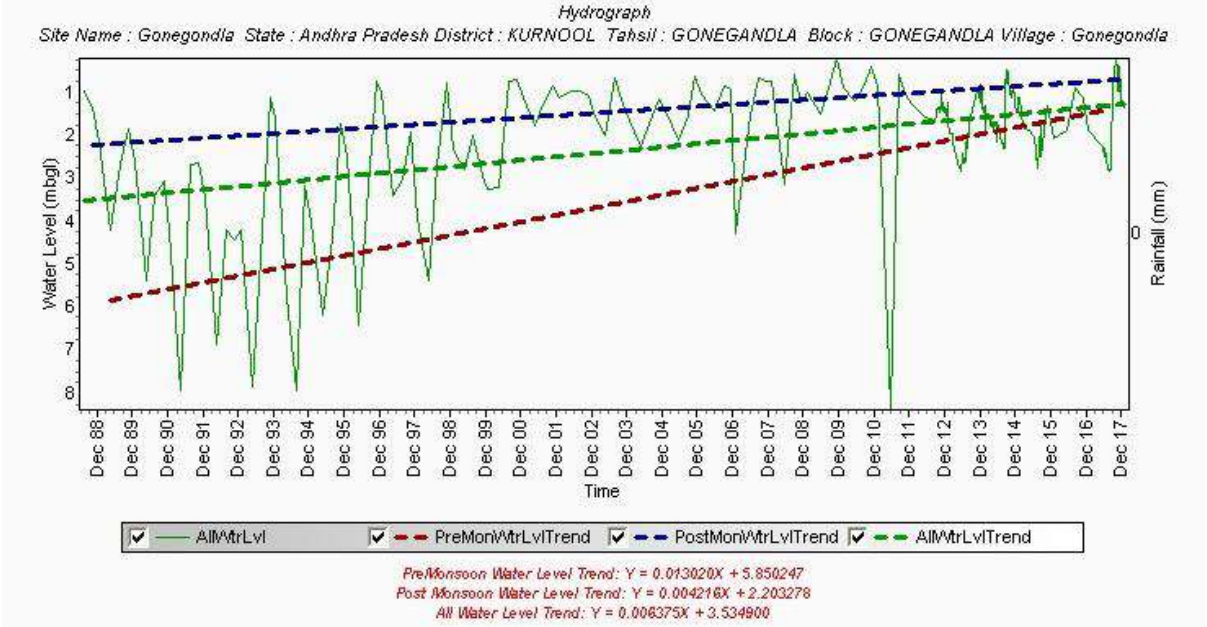

Hydrograph
Site Name : Chandalur State : Andhra Pradesh District : PRAKASAM Tahsil : DARSI Block : DARSI Village : Chandalur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009251X + 4.244122
Post Monsoon Water Level Trend: Y = 0.000984X + 4.214007
All Water Level Trend: Y = -0.000968X + 5.192271

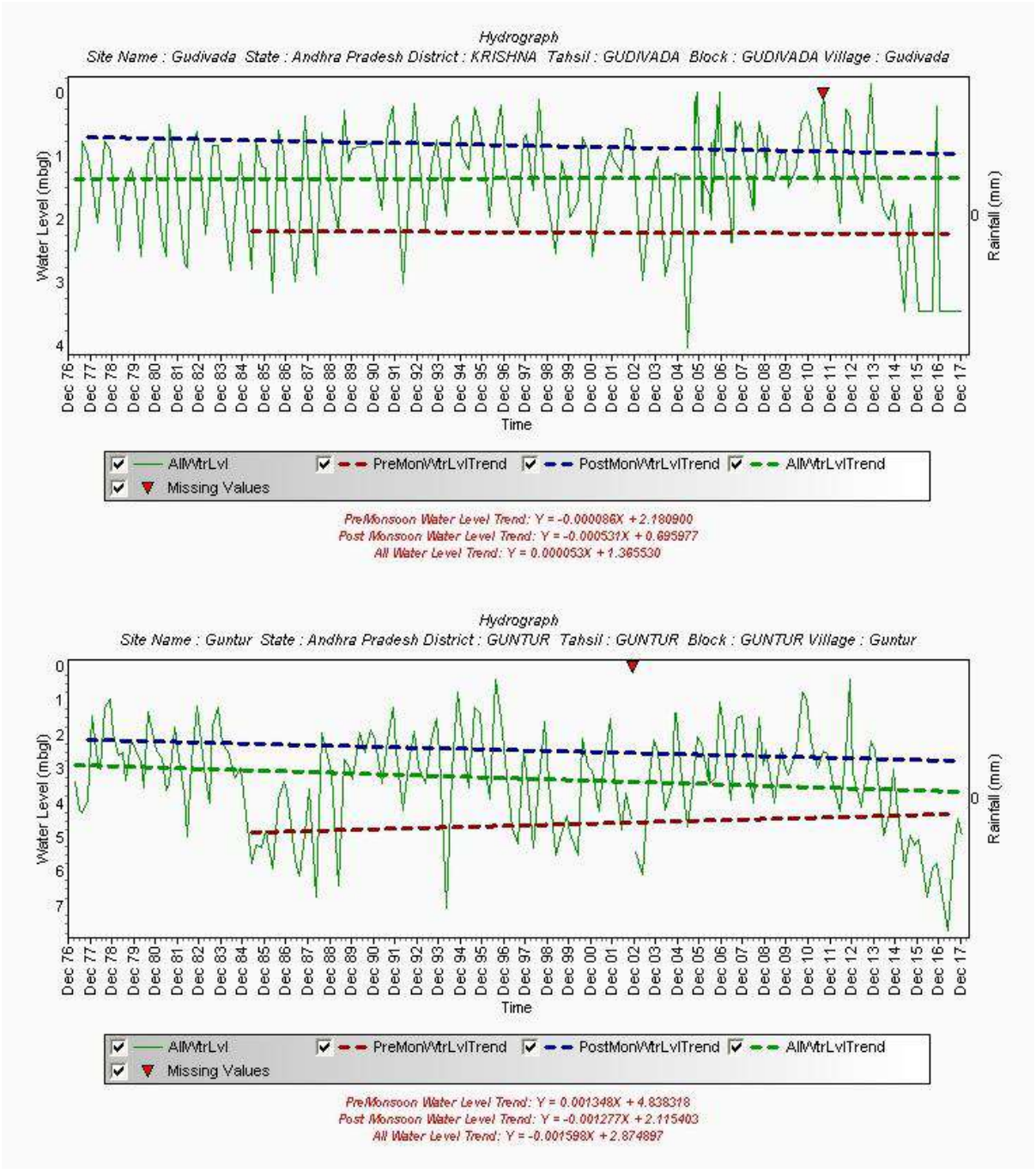

Hydrograph
Site Name : Chirala State : Andhra Pradesh District : PRAKASAM Tahsil : CHIRALA Block : CHIRALA Village : Chirala
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001061X + 2.579295
Post Monsoon Water Level Trend: Y = -0.000501X + 2.049399
All Water Level Trend: Y = -0.000438X + 2.425031
Hydrograph
Site Name : Damalcheruvu State : Andhra Pradesh District : CHITTOOR Tahsil : PAKALA Block : PAKALA Village : Damalcheruvu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.002283X + 7.486676
Post Monsoon Water Level Trend: Y = -0.001558X + 4.237083
All Water Level Trend: Y = -0.001847X + 5.070102

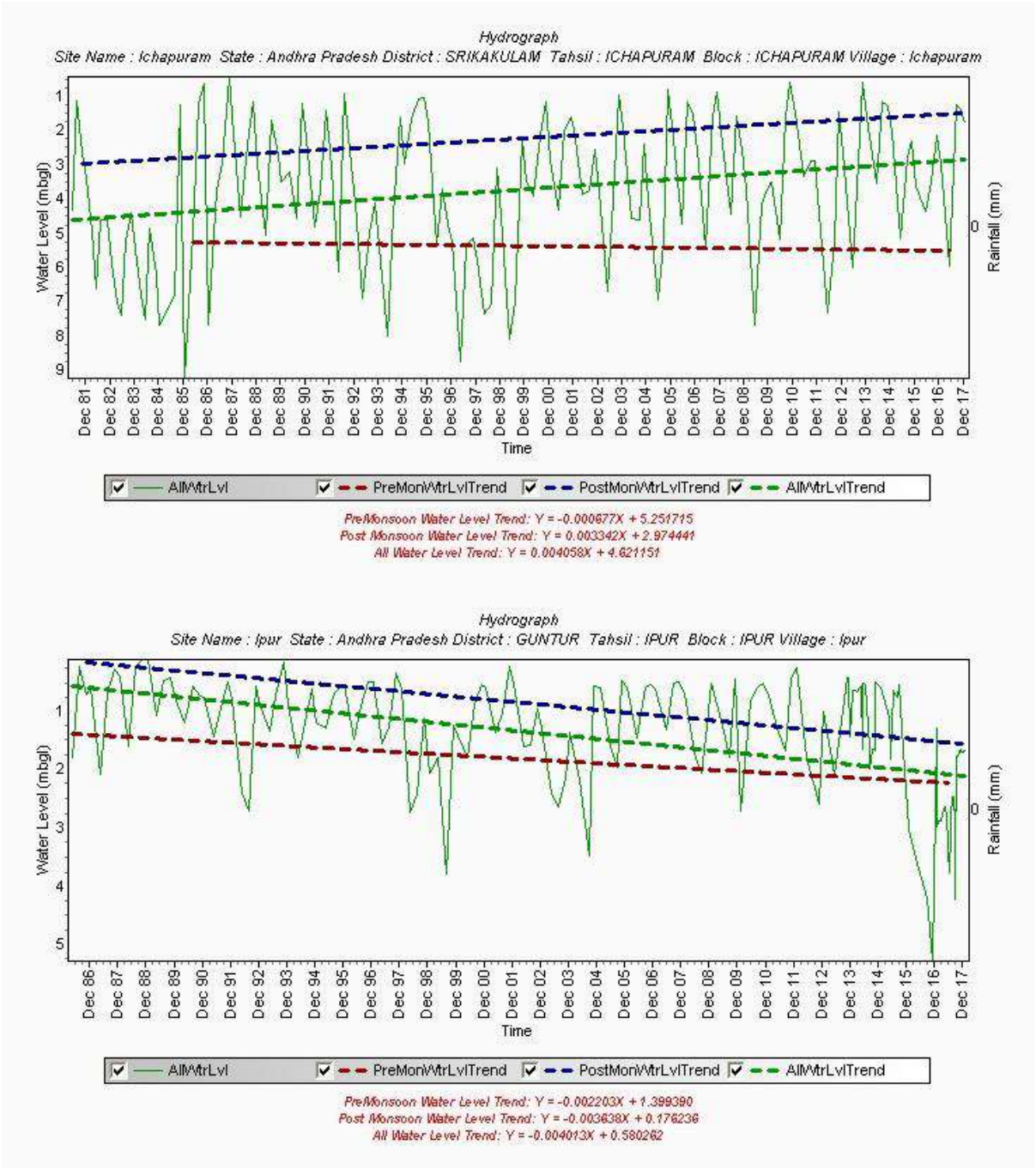

Hydrograph
Site Name : Eluru-PZ State : Andhra Pradesh District : WEST GODAVARI Tahsil : ELURU Block : ELURU Village : Eluru-pn
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.082291X + 7.776690
Post Monsoon Water Level Trend: Y = -0.072759X + 7.142885
All Water Level Trend: Y = -0.079677X + 6.311115

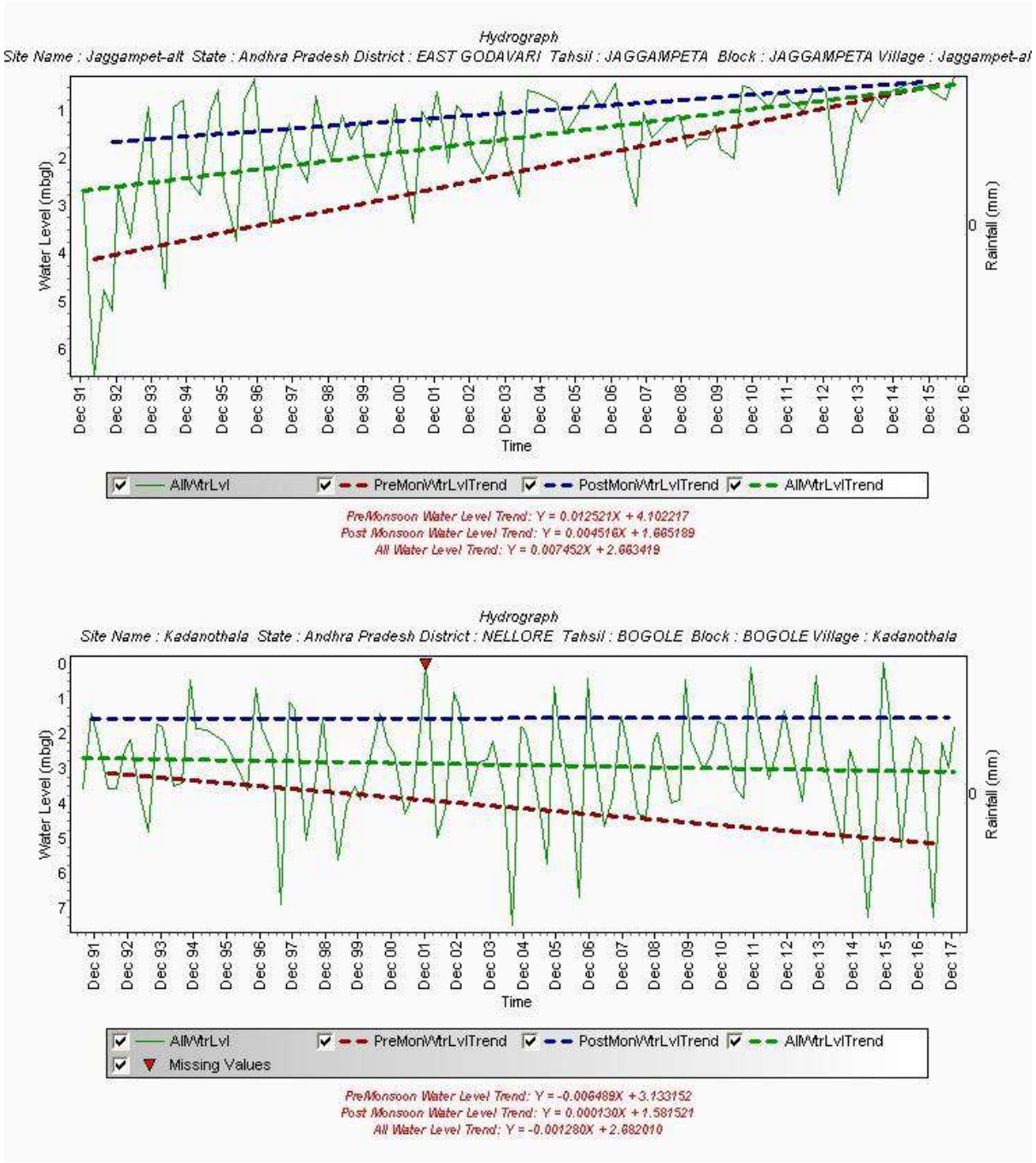

Hydrograph
Site Name : Garbham State : Andhra Pradesh District : VIZIANAGARAM Tahsil : MERAKAMUDIDAM Block : MERAKAMUDIDAM Village : Garbham
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001203X + 7.233307
Post Monsoon Water Level Trend: Y = -0.000641X + 2.883668
All Water Level Trend: Y = 0.000933X + 5.172613

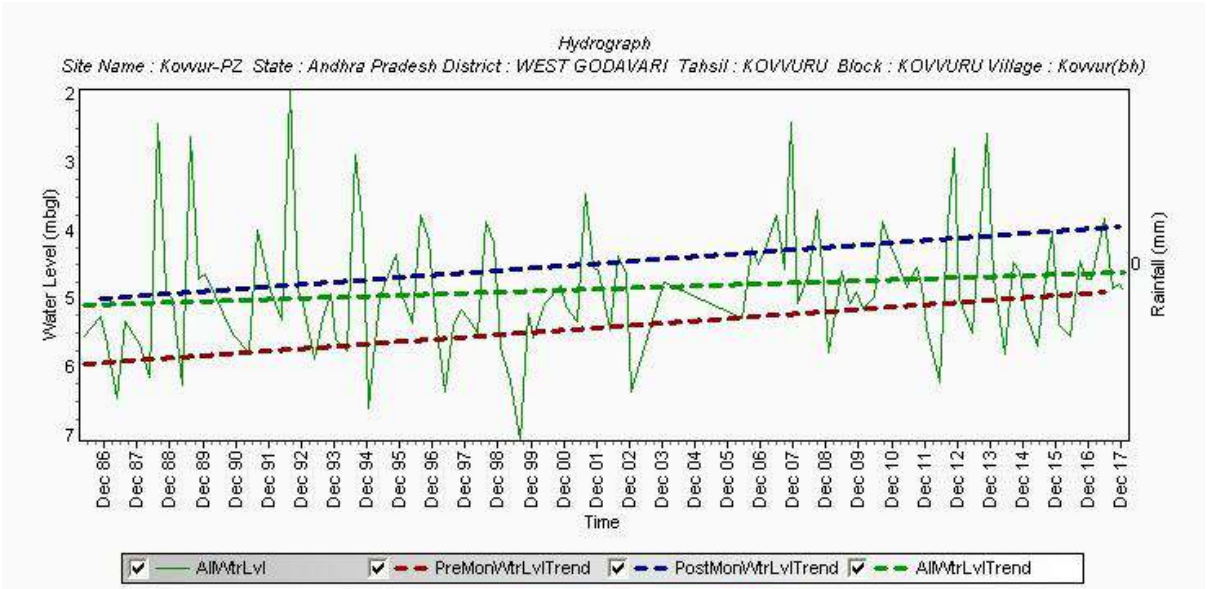

Hydrograph
Site Name : Gollaprolu State : Andhra Pradesh District : EAST GODAVARI Tahsil : GOLLAPROLU Block : GOLLAPROLU Village : Gollaprolu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001712X + 3.293354
Post Monsoon Water Level Trend: Y = -0.000154X + 1.360944
All Water Level Trend: Y = -0.000262X + 1.989200

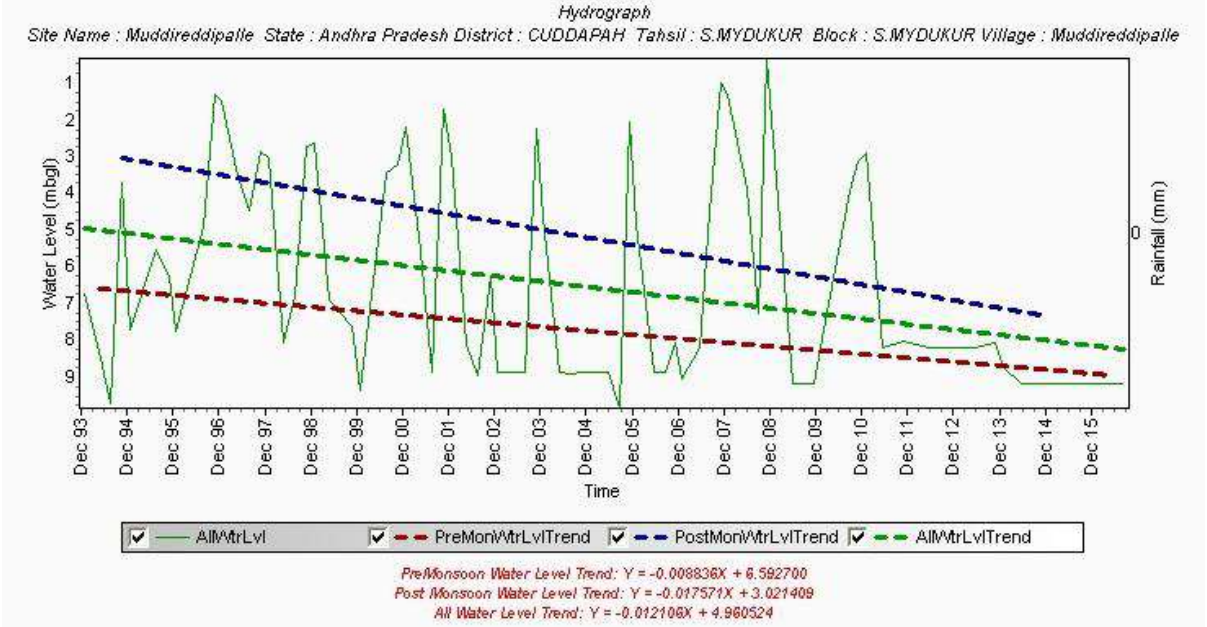

Hydrograph
Site Name : Gonegondla State : Andhra Pradesh District : KURNOOL Tahsil : GONEGANDLA Block : GONEGANDLA Village : Gonegondla
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.013020X + 5.850247
Post Monsoon Water Level Trend: Y = 0.004216X + 2.203278
All Water Level Trend: Y = 0.006375X + 3.534900


Hydrograph
Site Name : Gudivada State : Andhra Pradesh District : KRISHNA Tahsil : GUDIVADA Block : GUDIVADA Village : Gudivada
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.000086X + 2.180900
Post Monsoon Water Level Trend: Y = -0.000531X + 0.695977
All Water Level Trend: Y = 0.000053X + 1.365530
Hydrograph
Site Name : Guntur State : Andhra Pradesh District : GUNTUR Tahsil : GUNTUR Block : GUNTUR Village : Guntur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.001348X + 4.838318
Post Monsoon Water Level Trend: Y = -0.001277X + 2.115403
All Water Level Trend: Y = -0.001598X + 2.874897


Hydrograph
Site Name : Ichapuram State : Andhra Pradesh District : SRIKAKULAM Tahsil : ICHAPURAM Block : ICHAPURAM Village : Ichapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000677X + 5.251715
Post Monsoon Water Level Trend: Y = 0.003342X + 2.974441
All Water Level Trend: Y = 0.004058X + 4.621151
Hydrograph
Site Name : Ipur State : Andhra Pradesh District : GUNTUR Tahsil : IPUR Block : IPUR Village : Ipur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002203X + 1.399390
Post Monsoon Water Level Trend: Y = -0.003638X + 0.176236
All Water Level Trend: Y = -0.004013X + 0.580262


Hydrograph
Site Name : Jaggampet-alt State : Andhra Pradesh District : EAST GODAVARI Tahsil : JAGGAMPETA Block : JAGGAMPETA Village : Jaggampet-al
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.012521X + 4.102217
Post Monsoon Water Level Trend: Y = 0.004516X + 1.665189
All Water Level Trend: Y = 0.007452X + 2.663419
Hydrograph
Site Name : Kadanothala State : Andhra Pradesh District : NELLORE Tahsil : BOGOLE Block : BOGOLE Village : Kadanothala
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.006489X + 3.133152
Post Monsoon Water Level Trend: Y = 0.000130X + 1.581521
All Water Level Trend: Y = -0.001280X + 2.682010


Hydrograph
Site Name : Kovvur-PZ State : Andhra Pradesh District : WEST GODAVARI Tahsil : KOVVURU Block : KOVVURU Village : Kovvur(bh)
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.002729X + 5.937370
Post Monsoon Water Level Trend: Y = 0.002787X + 4.992407
All Water Level Trend: Y = 0.001237X + 5.082262


Hydrograph
Site Name : Muddireddipalle State : Andhra Pradesh District : CUDDAPAH Tahsil : S.MYDUKUR Block : S.MYDUKUR Village : Muddireddipalle
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.008836X + 6.592700
Post Monsoon Water Level Trend: Y = -0.017571X + 3.021409
All Water Level Trend: Y = -0.012106X + 4.960524

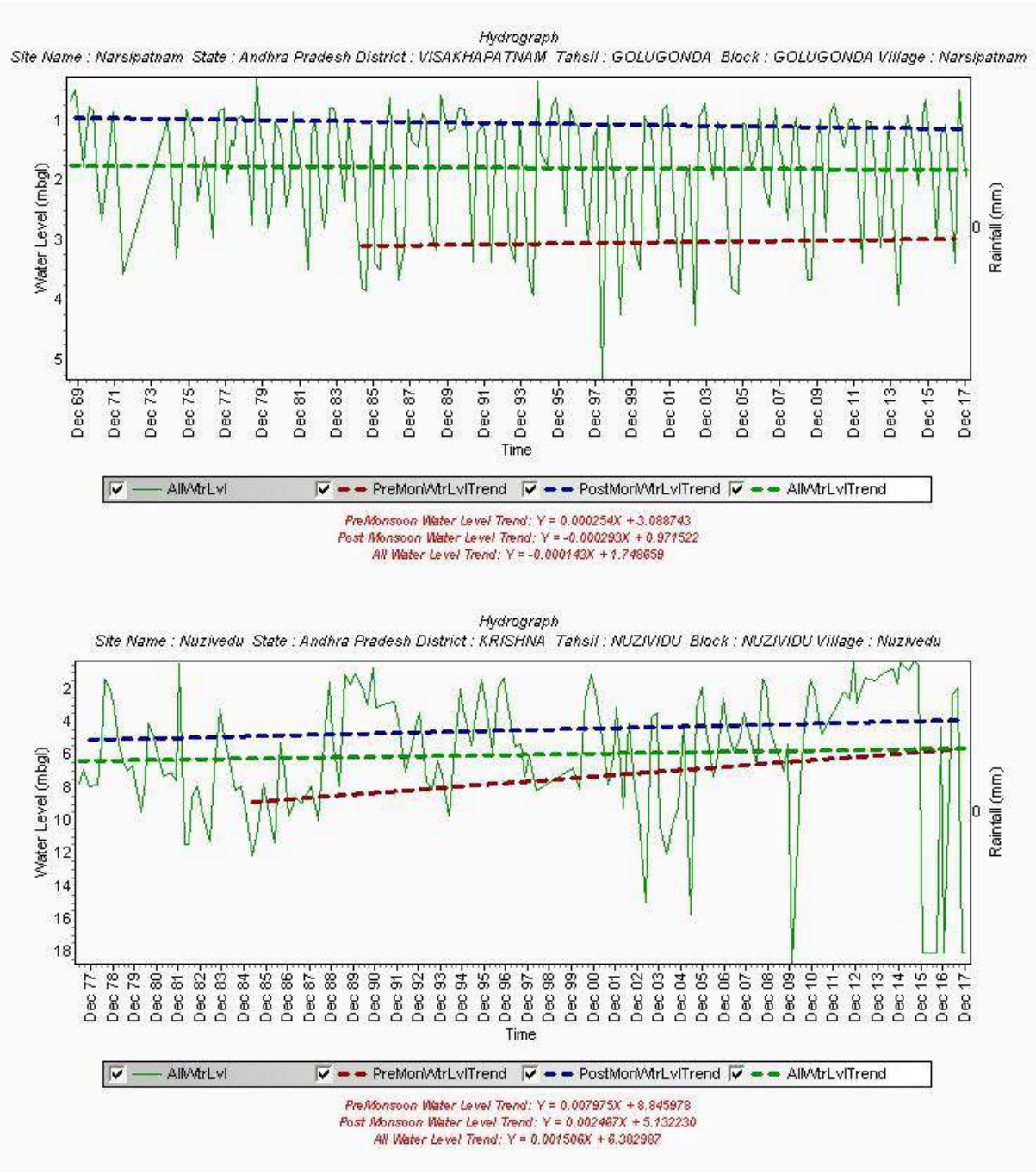


Fig.7.21: Representative Hydrographs from Andhra Pradesh State.

8. GROUND WATER QUALITY

Water is a universal solvent and therefore, chemical nature of groundwater forms the basis of interpretations of quality in relation to source, geology, climate and use.

8.1 Distribution of physico-chemical parameters

A total of 600 groundwater samples from shallow GWMS (both Dug Wells and Piezometers) were collected during pre-monsoon season of 2017 (May) for basic constituents **(Fig.8.1 and Table-8.1).** Samples are analyzed in the Regional Chemical Laboratory of CGWB, SR, (NABL Accredited). Sampling, preservation, and storage of groundwater have been carried out by following standard guidelines (APHA 1998). Fourteen major parameters such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{2-}) ,Bicarbonate (HCO^{3-}), Chloride (Cl^{-}), Sulphate (SO_4^{2-}), Nitrate (NO_3^{-}) andFluoride (F-), were determined. District wise minimum, maximum and average concentrations are given in Table- 8.2.

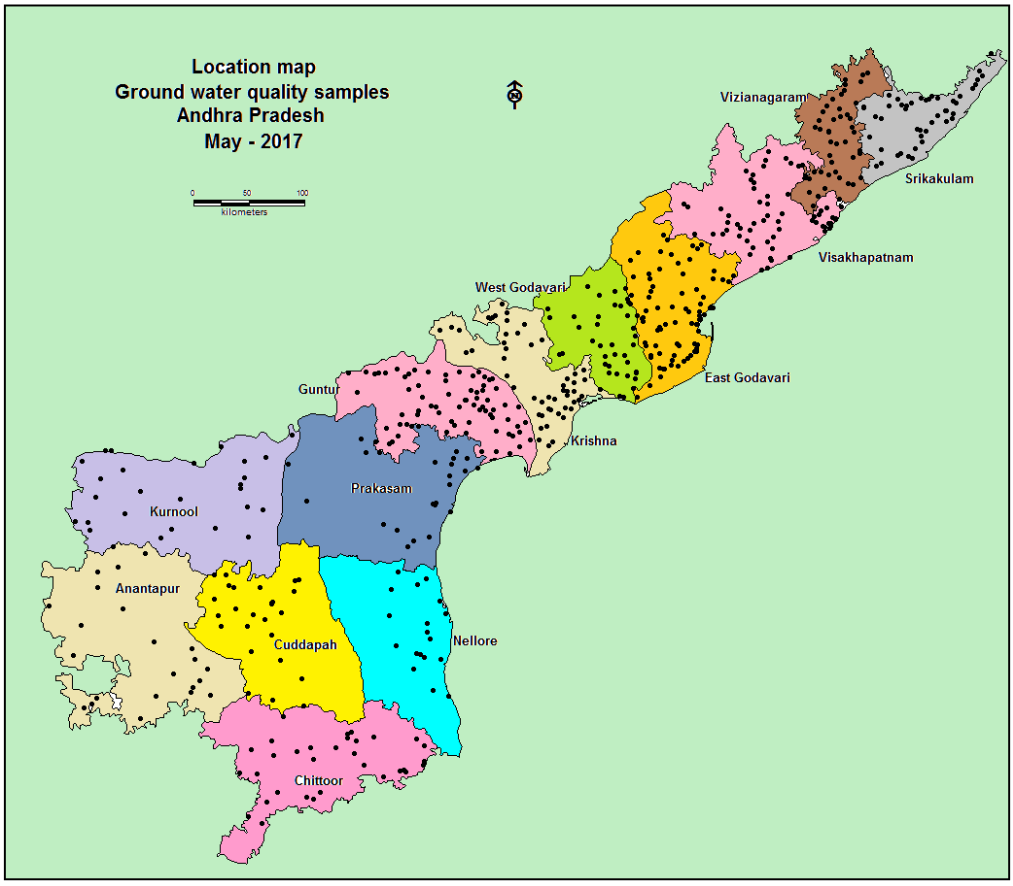


Fig.8.1: Location of Ground water sample sites in Andhra Pradesh

Table-8.1: District wise collection of samples (May-2017)

S.No.	District	Samples		S.No.	District	Samples
		Normal				Normal
1	ANANTAPUR	23		8	NELLORE	22
2	CHITTOOR	34		9	PRAKASAM	28
3	CUDAPAH	27		10	SRIKAKULAM	53
4	EAST GODAVARI	83		11	VISAKHAPATNAM	68
5	GUNTUR	75		12	VIZIANAGARAM	52
6	KRISHNA	57		13	WEST GODAVARI	47
7	KURNOOL	31			TOTAL:	**600**

8.1.1 pH- Hydrogen Ion Concentration

The hydrogen ion activity is a main variable of groundwater system because the hydrogen ion participates in most of the chemical reactions that affect water composition. In most natural waters pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. The pH value of a solution is the negative logarithm of concentration of hydrogen ions (H^+) in moles/liter. Pure water at 7 pH (at 25º C), contains equal proportion of H^+ and OH^- (hydroxyl) ions. The pH value is less than 7 if the H^+ ions exceed the OH^- ions, and it is more than 7 when OH^- ions exceed H^+ ions. In the ground waters of State, pH ranges from 6.15-8.88.In 4 samples (Kottur of Visakhapatnam district, Ongole PZ of Prakasam district and Diguvamanda, Gangaraivalasa of Vizianagaram district), pH is beyond permissible limit of BIS.

8.1.2 Electrical Conductivity (EC)

Electrical conductance (EC) of an electrolyte is the reciprocal of specific resistance and is expressed in µS/cm. Electrical conductivity normally, increases with flow and residence time in the aquifer and its determination shows, to what extent mineralization has taken place in the groundwater. In the study area, the EC values (µS/cm at 25°C) ranges from 292 -21560. Highest EC is noticed at Narasimhapuram of West Godavari district. In 86.5% of samples EC is in the range of 500-3000 µ S/cm and high ECs are detected in parts of Anantapur, Cuddapah and Coastal districts.

8.1.3 Total Dissolved Solids (TDS)

The concentration of TDS in groundwater depends upon nature of rock formation, depth through which water is passing, climate, geomorphology of the area at which water is

moving, porosity and permeability of rocks. Contamination of water by human and animal activities including sewage disposal and agricultural practices and mixing of different types of water also affects TDS.

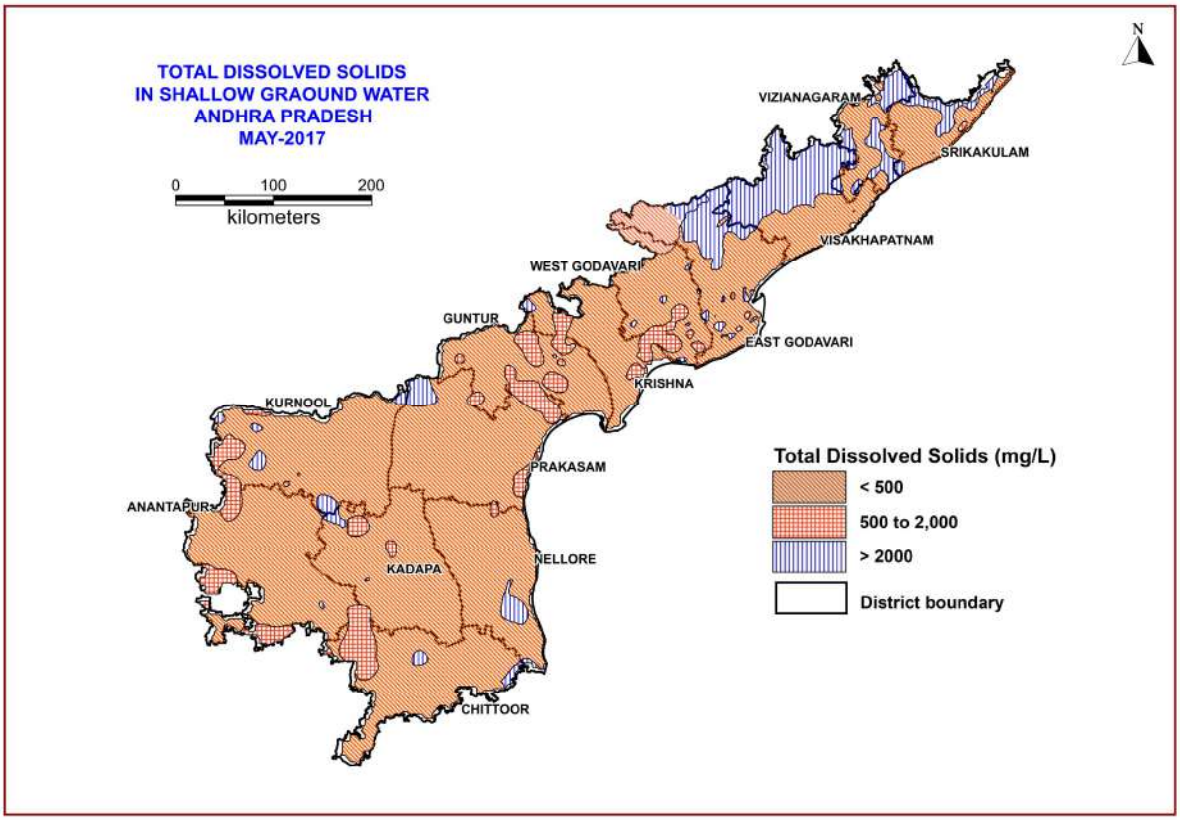


Fig.8.2: Distribution of TDS (May-2017).

The concentration of TDS in the state ranges from 33-12323mg/L (avg: 1116) and it is found that in 68 samples it is beyond permissible limit (2000 mg/L)**.** Distribution of TDS is given in **fig 8.2**.

8.1.4 Total Hardness (TH)

Total hardness is the capacity of water to neutralize soap and is the sum of $Ca^{2+}$and Mg^{2+}. Hardness is of two types, namely primary and secondary. In the state, Total Hardness ranges from 25-4300 mg/L and it is found that in 114 samples hardness is beyond permissible limits of BIS (600 mg/L).

8.1.5 Calcium (Ca^{2+})

In most of the naturally occurring groundwater, calcium is the main cation due to its abundance in earth's crust and high mobility. The principal sources of calcium in groundwater are minerals present in igneous rocks, especially silicates, like pyroxenes, amphiboles, feldspars and sedimentary rocks like limestone, dolomite and gypsum. It is also present in the form of adsorbed ions on negatively charged mineral surfaces in soils and rocks.

The concentration of calcium ranges from 4.0 - 661mg/L and it is found that in 34 samples, Ca is beyond permissible limit (200 mg/L). In almost all districts Ca is below permissible limit is and maximum of 661mg/L is detected in Narasimhapuram of West Godavari district.

8.1.6 Magnesium (Mg^{2+})

Weathering of basic igneous rocks such as dunites, pyroxenites; volcanic rocks such as basalts; metamorphic rocks like amphibolites, talc and tremolite-schists; sedimentary rocks such as dolomite, gypsum etc are the main sources of Mg^{2+} in the groundwater (Karanth, 1987) and use of surface water for irrigation is another source of Mg^{2+} in the groundwater (Hem, 1991). In the state, as in most natural water, the magnesium concentration is much lower than the calcium concentration (Hem, 1991). It ranges from 1.33-644.5mg/L with an average of 53mg/L. Except in Krishna, in all other districts Mg is well below permissible limits. Maximum concentration is detected in Narasimhapuram of West Godavari district.

8.1.7 Sodium (Na^{+})

Silicate minerals such as albite, nepheline, sodalite, glaucophane, aegerine and other Na+ bearing minerals present in rocks are the main source of Na+ in the groundwater. The other sources are rainwater, dissolution of evaporate minerals, sodium disposal through sewage and industrial wastes (Handa, 1975). Certain clay minerals and zeolites can increase the sodium concentration in groundwater by Base Exchange reaction **(Karanth, 1987).** The concentration of Na^{+} ranges from 2.0 to 3094mg/L. with an average concentration of 202mg/L. The highest concentration is detected in Narasimhapuram of West Godavari district.

8.1.8 Potassium (K^+)

The common source of K^+ in groundwater is due to weathering of silicate minerals like orthoclase, microcline, nepheline, biotite, leucite etc. Dissolution of evaporites containing highly soluble sylvite and nitre in sedimentary rocks are the other sources of K^+ in the ground waters **(Handa, 1975; Karanth, 1987).** Anthropogenic sources such as fertilizers, manure, human and animal wastes and intrusion of saline waters due to over pumping are some of the other sources of K^+ in ground waters.

The concentration of K+ ranges from below detectable limits to 860 mg/L. The average concentration is 40 mg/L and the highest concentration is detected in dugwell of Kanchisamudram village (Anantapur district).

8.1.9 Carbonate and Bicarbonate ($CO_3^{--}$and HCO_3)

The main source of CO_3^- and HCO_3^- ion in the groundwater is dissolved CO_2 present in rainwater. When this rainwater enters soil, it dissolves more CO_2 from decaying organic matter present in soil **(Karanth, 1987).** An increase in temperature or decrease in pressure causes reduction in the solubility CO_2 in groundwater. Carbon dioxide mixed water, while passing through soil dissolves carbonate minerals and give bicarbonate.

The occurrence of carbonates in groundwater is mainly dependent on its pH. In groundwater, carbonates are generally present when pH of groundwater is above 8.3 and it is in traces or absent when pH of water is less than 8.3 (**Handa, 1975; Hem, 1991; Karanth, 1987).** Under normal conditions the bicarbonate concentration in groundwater ranges between 100 to 800 mg/L.

In the ground waters of State, the concentrations of bicarbonate ranges from 18 to 1305mg/L, with an Average concentration of 434mg/L and highest concentration is detected in Palakol dug well of West Godavari district.

8.1.10 Chloride (Cl^-)

Chloride in the form of chloride (Cl-) is one of the major in-organic anion in water and wastewater **(APHA, 1995).** Hydrolysis of halite and related minerals, rainwater, irrigation and industrial effluents are the main sources of Cl^- in groundwater **(Handa, 1975).**

Minerals like sodalite, mica, chloro-apatite, hornblende, etc are the other minor sources of chloride in groundwater **(Karanth, 1987).** Abnormal concentration of Cl^- in groundwater may results due to pollution of sewage wastes, planting of coconut trees **(Karanth, 1987).**

In the ground waters of State, chloride concentration ranges from 5.0 to 7374mg/L with an Average of 287 and 24 samples are unsuitable for drinking purposes. Maximum concentration is detected in Narasimhapuram of West Godavari district.Distribution of Chloride is given in **fig 8.3.**

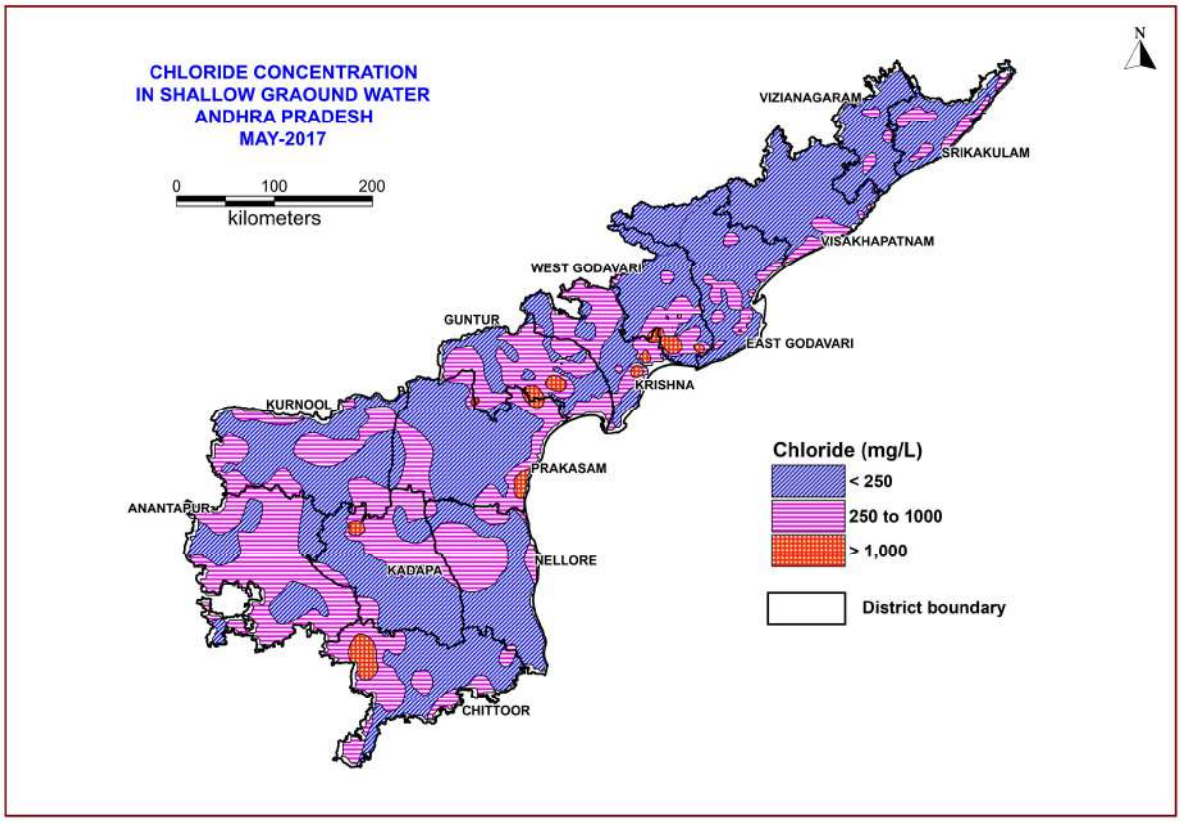


Figure 8.3 Distribution of Chloride in ground water (May-2017).

8.1.11 Sulphate (SO_4^{2-})

Sulphate (SO_4^{2-}) is widely distributed in native and may be present in natural waters in concentration ranging from a few to several thousand mg/L (APHA, 1998). The main sources of SO_4^{2-} in groundwater are sulphide minerals like pyrite, gypsum and anhydrite minerals found in sedimentary rocks (Karanth, 1987).

In the ground waters of the state, the concentration of sulphate ranges from 16-2957mg/L. Maximum concentration detected in Karamchedu of Prakasam district.

8.1.12 Nitrate (NO_3^-)

Nitrogen is present in atmosphere reacts with rainwater and forms nitrate and ammonium ions. The incidence of high nitrate in groundwater has been observed due to pollution from anthropogenic sources, specially leaching from sewage/septic tanks **(Walker, 1973; Dudley, 1990).**

In the ground waters of State, the concentrations of Nitrate range from 0-959mg/L. Maximum concentration detected in Thulluru well (Guntur district). It is found that out of 600 samples nearly 208 samples (34.7%) are unfit for human consumption. Nitrate distribution is presented in **Fig.8.4**.

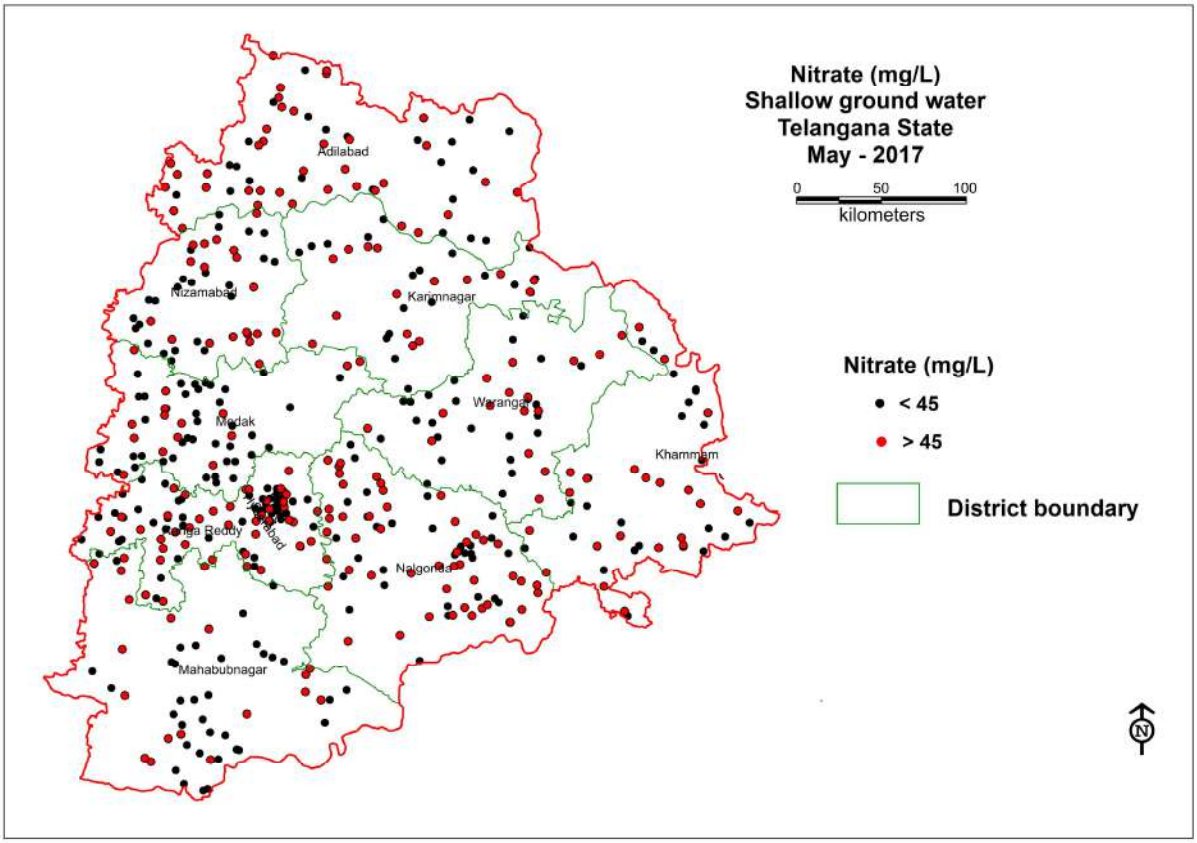


Fig.8.4: Point values of Nitrate in ground water (May-2017).

8.1.13 Fluoride (F^-)

The main sources of Fluoride in ground waters are Fluoride bearing minerals present in rocks like Fluorite (CaF_2), Apophyllite ($KCa_4Si_8O_{20}(F,OH)$ $8(H_2O)$, Fluoroapatite ($Ca_5(PO_4)_3F$), Cryolite (Na_3AlF_6), Villuanite as well as Fluoride replacing hydroxyl ion in the ferromagnesium silicates (amphiboles, micas) and soil consisting of clay minerals. Dissolution of F- bearing minerals, ion exchange and evaporative concentration can locally

account for high F- concentration in ground water. Weathering of rock and leachable Fluoride in an area are more important in deciding the presence of Fluoride in groundwater rather than presence of Fluoride bearing minerals in bulk rocks/soils (Ramesham and Rajagopalan 1985).

In the ground waters of State, the concentrations of fluoride range from 0.09-3.82mg/L and maximum concentration is detected in Reddigudem of Krishna district. Out of 600 total samples, 42 (only 7.0 %) are unfit for human consumption. Higher concentration of F (>1.5 mg/L) are detected in few districts of the state **(Fig.8.5).**

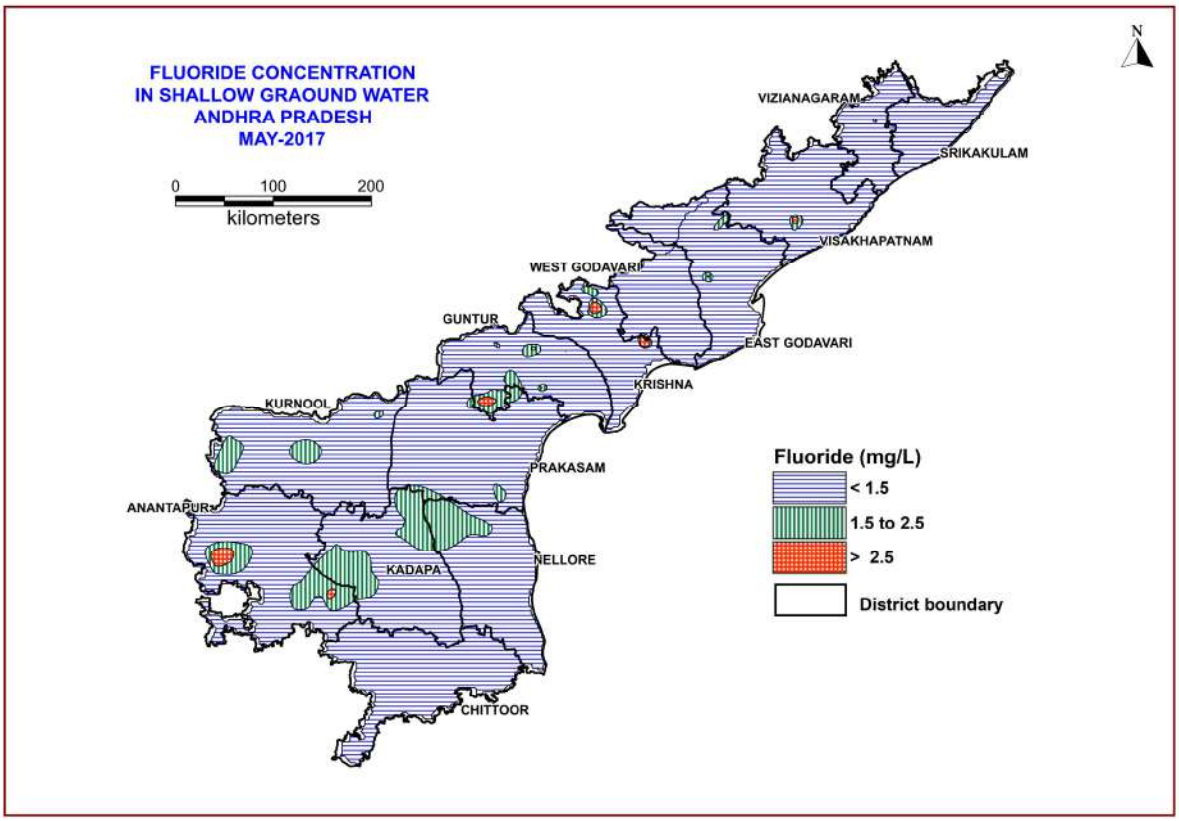


Fig.8.5: Fluoride in ground water (May-2017).

8.2 Quality of ground water for drinking purpose

The hydro chemical data is compared with the drinking water quality standards set by Bureau of Indian Standards (BIS) to assess the suitability of ground water from shallow aquifers in Andhra Pradesh, for drinking purposes. The suitability of the ground water samples collected from shallow aquifers for drinking purposes with reference to chemical parameters is presented in Table 8.3.

Total Dissolved Solids (TDS) in 1.7 % of samples is beyond permissible limit of BIS. Out of which, highest percent of samples in Guntur (60 %), Kurnool (20%) and Prakasam (20%) districts are unsuitable for drinking with respect to TDS. Chloride Content in 4.0% of samples in the state exceeds the BIS permissibility. The Nitrate content in 34.7% of samples of the state is exceeding the BIS permissible value indicating the anthropogenic contamination, which is less than the previous years. Out of 208 samples, highest percent of samples in Guntur (22.6%), followd by Visakhapatnam (10.6%) and East Godavari (10 %) districts are unfit for drinking.

Fluoride content in the state varies from 0.09 to 3.82mg/L, with an average of 0.65mg/L. 6.5% of samples in the state exceed BIS permissible limit. Highest percent of samples in Guntur (28.2%) followed by Kadapa (17.9%) district unfit for drinking purposes.

Table- 8.2 Suitabilityof Samples with respect to different constituents for drinking purpose (IS-10500: 2012)

District	TH (600)	Ca (200)	Mg (100)	HCO_3 (600)	Cl (1000)	SO_4 (400)	NO_3 (45)	F (1.5)	TDS (2000)
% Samples Exceeding permissible limit									
Andhra Pradesh	**19.0**	**5.7**	**11.0**	**18.2**	**4.0**	**4.7**	**34.7**	**7.0**	**11.3**
Anantapur	43.5	13.0	8.7	56.5	0.0	4.3	52.2	21.7	13.0
Chittoor	17.6	11.8	2.9	8.8	2.9	0.0	32.4	0.0	2.9
Cuddapah	18.5	11.1	7.4	22.2	7.4	7.4	29.6	25.9	18.5
East Godavari	13.3	3.6	8.4	16.9	4.8	2.4	25.3	2.4	10.8
Guntur	32.0	9.3	17.3	29.3	5.3	6.7	62.7	14.7	21.3
Krishna	35.1	8.8	29.8	36.8	10.5	12.3	29.8	5.3	17.5
Kurnool	19.4	6.5	12.9	16.1	0.0	12.9	41.9	16.1	22.6
Nellore	4.5	0.0	4.5	9.1	0.0	4.5	36.4	4.5	9.1
Prakasam	21.4	3.6	17.9	21.4	10.7	14.3	46.4	14.3	25.0
Srikakulam	9.4	0.0	5.7	0.0	0.0	0.0	24.5	0.0	3.8
Visakhapatnam	8.8	1.5	4.4	13.2	0.0	1.5	32.4	4.4	1.5
Vizianagaram	5.8	1.9	1.9	1.9	0.0	0.0	32.7	1.9	0.0
West Godavari	23.4	8.5	14.9	14.9	8.5	2.1	12.8	0.0	12.8

8.3 Quality of ground water for irrigation Purposes

The most extensive use of ground water in the world is for the irrigation consumption. The chemical quality of ground water is an important factor to be considered in evaluating its usefulness for irrigation as poor quality ground water may cause salinity, specific ion toxicity or infiltration problem in soils. Such effect may adversely affect crop production.

Water quality constraints in irrigation can be examined using a number of empirical indices that have been established on the basis of field experience and experiments.

8.3.1 US salinity laboratory classification

The laboratory has constructed a diagram and described 16 classes with reference to Sodium Absorption Ratio (SAR) as an index for sodium hazard and electrical conductivity as an index for salinity hazard. SAR is defined as

$$SAR = (Na^{+})/Sqrt\{(Ca^{+2}+Mg^{+2})/2\}$$

Concentrations are expressed in meq/L.

The samples collected from the monitoring wells in Andhra Pradesh fall into 9 classes as described below.

C_1S_1: Low salinity and low sodium waters are good for irrigation and can be used with most of the crops with no restriction on use on most of the soils.

C_2S_1: Medium salinity and low sodium waters are good for irrigation and can be used on all most all soils with a little danger of development of harmful levels of exchangeable sodium if moderate amount of leaching occurs. Crops can be grown without any special consideration for salinity control.

C_3S_1: The high salinity and low sodium waters require good drainage. Crops with good salt tolerance should be selected.

C_3S_2: The high salinity and medium sodium waters require good drainage and can be used on coarse textured or organic soils having good permeability.

C_3S_3: These high salinity and high sodium waters require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendments make feasible the use of these waters.

C_4S_1: Very high salinity and low sodium waters are not suitable for irrigation unless the soil must be permeable and drainage must be adequate. Irrigation waters must be applied in excess to provide considerable leaching. Salt tolerant crops must be selected.

C_4S_2: Very high salinity and medium sodium waters are not suitable for irrigation on fine textured soils and low leaching conditions and can be used for irrigation on coarse textured or organic soils having good permeability.

C_4S_3: Very high salinity and high sodium waters produce harmful levels of exchangeable sodium in most soils and will require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendments make feasible the use of these waters.

C_4S_4: Very high salinity and very high sodium waters are generally unsuitable for irrigation purpose. These are sodium chloride type of waters and can cause sodium hazard. Can be used on coarse textured soils with very good drainage for very high salt tolerant crops. Gypsum amendments make feasible the use of these waters.

Fig. 8.6 shows the US salinity diagram of all water samples of the state. It is observed that 52.3% of water samples are falling in C_3S_1 class, 12.2% in C_2S_1 class, 4.2% of samples falling in C_3S_2 class. 2.8%, 8.2 and 10.2%, samples falling in C_1S_1, $C_3S_2$and C_4S_2 respectively. Rest of the samples falls in C_3S_3 (1.0%), C_4S_3 (3.5%), and C_4S_4 (1.0%) classes. About 4.7% samples do not fall in any class and the salinity of those samples is beyond the classification.

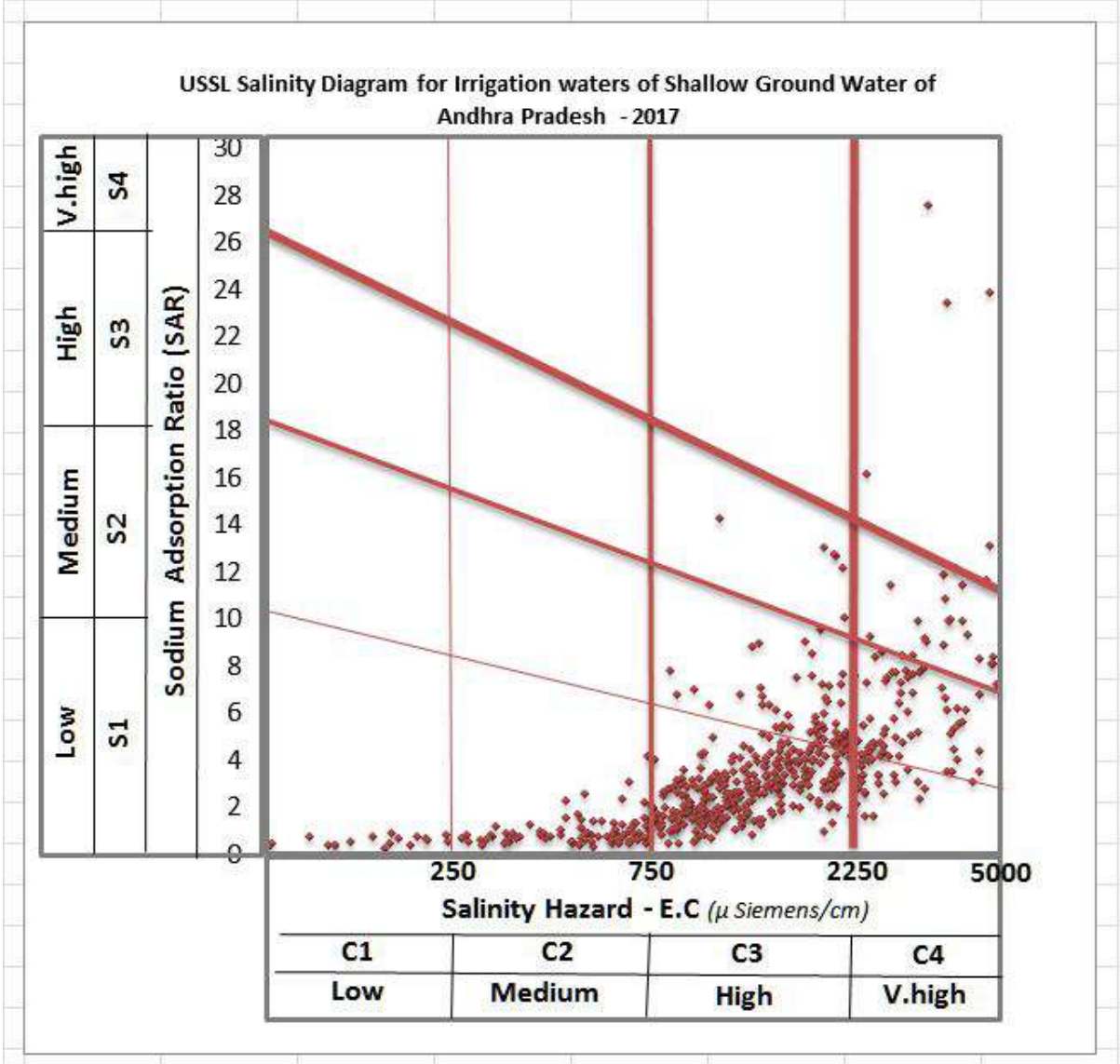


Fig. 8.6 U.S. Salinity diagram for classification of irrigation waters for shallow aquifers of Andhra Pradesh -2017

8.3.2 Residual Sodium Carbonate (RSC)

The RSC is defined as the excess of carbonate and bicarbonate amount over the alkaline earths (Ca^{2+} and Mg^{2+}). Use of RSC beyond permissible limit (>2.5) adversely affects irrigation. The tendency of Ca^{2+} and Mg^{2+} to precipitate, as the water in the soil becomes more concentrated, as a result of evaporation and plant transpiration, and gets fixed in the soil by the process of base exchange, thereby decreasing the soil permeability.

Distribution of ground water in the state as per RSC given in **Table 8.3** and it reveals, majority of samples (81.2%) fall in safe class (RSC < 1.25), 7.0 % in marginal category and remaining 11.8% in not suitable category.

Table-8.3: **Classification of Ground water based on RSC.**

RSC	Category	No of samples	% of samples
<1.25	Safe	487	81.2
1.25 - 2.50	Marginal	42	7.0
> 2.50	Not Suitable	71	11.8

8.4 Water quality for livestock and poultry

Though there are no livestock standards regulated in India, basing on FAO and other international organizations standards, the water quality was classified for livestock and Poultry. One of the important parameter is Salinity/Electrical Conductivity, which moderately shows the suitability of most of the samples in usable. Magnesium and Nitrate are other important parameters to be considered for the usage of ground water for the livestock. Magnesium is also within the range specified. **Tables 8.4, 8.5 and 8.6** show water quality in relation to salinity, magnesium and nitrate for livestock.

Table-8.4 Use of ground water for livestock and poultry

Soluble salt content	Rating	No of samples in the range	Uses
< 1000 mg/Litre (<1.5 dS/m)	Excellent	359	Excellent for all classes of livestock and poultry
1000-3000 mg/Litre (1.5-5 dS/m)	Very satisfactory	216	Satisfactory for all classes of livestock. May cause temporary mild diarrhea in livestock not accustomed to them. Those waters approaching the upper limits may cause some watery droppings in poultry.
3000-5000 mg/Litre (5-8 dS/m)	Satisfactory for livestock Unfit for poultry	19	Satisfactory for livestock but may be refused by animals not accustomed to it. If Sulphate salts predominate, animals may show temporary diarrhea. Poor waters for poultry, often causing watery fasces, increased mortality and decreased growth especially in turkeys.
5000-7000 mg/Litre (8-11 dS/m)	Limited use for livestock Unfit for poultry	4	This water can be used for livestock except for those that are pregnant or lactating. It may have some laxative effect and may be refused by animals until they become accustomed to it. It is unsatisfactory for poultry
7000-10000 mg/Litre (11-16 dS/m)	Very limited use	1	Considerable risk for pregnant and lactating cows, horses, sheep and for the young of these species. It may be used for older ruminants or horses. Unfit for poultry and probably swine.
> 10000 mg/ litre (> 16 dS/m)	Not recommended	1	This water is unsatisfactory for all classes of livestock and poultry.

Source: FAO, 1985b, and Guyer, 1996.

Table-8.5: Suggested limits for magnesium in drinking water for livestock

Livestock	No of Samples within the range	Magnesium (mg/L)	Concentration (me/l)
Poultry[2]	596	<250	<21
Swine[2]	596	<250	<21
Horses	596	250	<21
Cows (lactating)	596	250	<21
Ewes with lambs	596	250	<21
Beef cattle	596	400	33
Adult sheep on dry feed	598	500	41

[1] Adapted from Australian Water Resources Council (1969).
[2] The tolerance of swine and poultry for magnesium is unknown but could well be less than 250 mg/L.

Table-8.6: Guide to use of waters containing nitrates for livestock.

Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO_3-N)**	Nitrate, NO_3	No samples in the range	Comments
Less than 100	<440	513	Experimental evidence indicates this water should not harm livestock or poultry.
100 to 300	440 - 1320	67	This water by itself should not harm livestock or poultry. If hays or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep, or horses.
More than 300	> 1320	20	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, use of this water for swine or poultry should be avoided.

Source : Water Quality for Livestock and Poultry, FO-1864-GO. University of Minnesota Extension Division, 1990.
**** The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO_2-N) because of the greater toxicity of the nitrite form.***
*****1 ppm of nitrate nitrogen is equivalent to 4.4 ppm of nitrate (NO_3).***

8.5 Groundwater facies

For identification of different water facies of groundwater, Piper diagram is widely used as it gives best graphical representation (**Hill, 1940; Piper 1944**). Groundwater can be grouped broadly into 10 types (**Fig.8.7**). Ground water from the area is mainly of Na-Mg-HCO_3-Cl and Na-Ca-HCO_3-Cl type followed by Na-Mg-Cl-HCO_3, Ca-Na-HCO_3-Cl type.

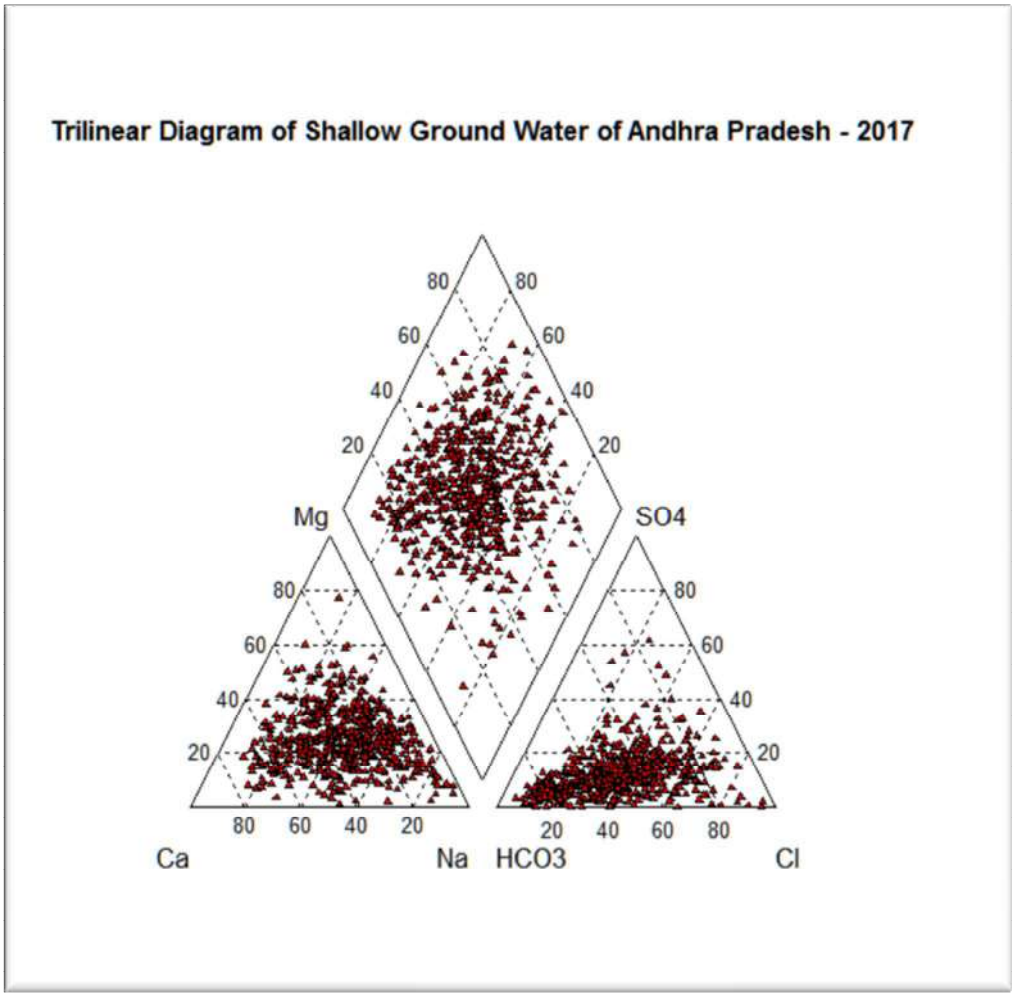


Fig.8.7: Ground water facies (Piper Plot)-May-2017.

9.0 SUM-UP

Central Ground Water Board, Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India, has been carrying out ground water regime studies all over the country for generating historical data base in order to establish dynamics of ground water regime which plays a crucial role for estimation of ground water resource.

Andhra Pradesh state covering ~1.63 lakh Km^2 lies between NL 12° 37' and 19° 09' and EL 76° 45' and 84° 47' and governed administratively by 13 districts. The total population of the state is ~4.96 crores and shown a decadal growth of 9.2 %. Drainage of the state can be divided into 3 major and 11 medium and ~60% of the soils are red in colour.

Forests occupy ~23% of the area and net sown area is ~38%. About 75% of the irrigation is contributed by ground water and the rest by surface water.

The mean annual rainfall during 2017 is 898 mm. Season-wise rainfall is 652 mm, 203 mm, 0 mm and 43 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 73 of annual rainfall in southwest monsoon, 23% in north-east and 4% in non-monsoon seasons. The annual (2017) rainfall ranges from 589 mm in Anantapuramu district (more from normal by 3%) to 1274 mm (more by 9%) in Srikakulam district.

A major part of the state is underlain by gneissic complex with a structural fill of sedimentary formations and basin-fill of meta-sedimentary formations. The gneissic complex is overlain by basaltic lava flows in the northwestern part and is intruded by several younger rocks namely granites, dolerites, pegmatite's and quartzite etc.

The annual replenishable ground water resources are 20,387 MCM, net ground water availability is 18,474 MCM, annual gross ground water draft is 8,104 MCM, allocation for future domestic and industrial use is 1,644 MCM and net ground water availability for future irrigation use is 10,210 MCM. The average stage of ground water development is 44% and out of 670 mandals , 61 fall under over-exploited category, 17 falls under critical, 54 under semi-critical and rest 538 under safe category including 73(41 Full, 32 Partial) mandals of poor-quality.

Ground water monitoring is carried out as part of National ground water monitoring programme 4 times a year (January, May, August and November) and ground water quality once in a year (May). As on 31/03/2018, total of 875 (DW: 727 and Pz: 148) Ground Water Monitoring Wells (GWMS) are in existence. There are 151 observers appointed to monitor GWMS on participatory mode (all dug wells).

Density of wells varies from 102 Km^2/well (East Godavari district) to 310 Km^2/well in Kurnool district with average of 183 Km^2/well. In the state, Softrocks have 336 monitoring stations and hardocks have 439 monitoring stations.

In general, the water levels are deep during May and shallow during November months. During May (pre-monsoon season) water levels are in the range of -0.25 m bgl to 49.3 m bgl and water levels in the range of les than 10 m m bgl are more predominant occupying ~71% of the area. Shallow water levels (0 to 2 m bgl) and deep water levels (>20 mbgl) occupy ~1 % and 5% of the area respectively.

During August (mid-monsoon season) water levels are in the range of -0.36 m bgl to 47.5 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~33% of the area followed by 10-20 mbgl (22% area). Shallow water levels less than 2 m occupy about 14% of the area. Deep water levels (>20 mbgl) occupy ~3.13 % of the area.

During November (post-monsoon season) water levels are in the range of -0.8 m bgl to 39.5 m bgl. Shallow water level range 0 to 2 m bgl is observed in 13% of the total area. Water levels in the range of 2-5 m bgl are occupying ~21 % of the area followed by 5-10 m bgl mbgl (33 % area). Deep water levels (>20 mbgl) occupy ~2 % of the area. Majority of water levels are in the range of 2 to 10 m bgl(68%).

Area with deep water levels has changed from 5% in May to 2 % in November. Area under shallow water levels changed from 1% in May to 13% in Nov .

During January-18, water levels are in the range of -0.70 m bgl to 104.1 m bgl and water levels in the range of 2-5 m bgl are more predominant occupying ~43 % of the area followed by 5-10 mbgl (33 % area). Shallow water levels (0-2 mbgl) occupy ~11 % and deep water levels (>20 mbgl) occupy ~3 % of the area.

Integrated water level data from CGWB and GWD (Ground Water Department, Govt of Andhra Pradesh) has been considered to analyse to get a water level scenario based more dense data. Water level data from GWD is based on realtime monitoring of water level from DWLR of telemetry. The range of water level in pre-monsoon ranges from 0.35 m bgl (East Godavari district) to 113.9 m bgl (Kadapa district). In post-monsoon season it ranges from -0.30 m (artesian condition) in Kurnool district) to 104.4 m bgl (Anantapuramu district). Majority of water level in pre-monsson is in the range of 5 – 10 m bgl. Majority of water level in post-monsson is in the range of 2-5 m bgl. Deep water levels (> 20 m bgl) has decreased from 25.2% to 11.1% of the well in the state. Shallow water levels have increased from 3% to 16% from pre to post-monsoon season due to good monsoon rains..

Water level fluctuation of Aug, 2017 with pre-monsoon water level of May, 2017 have shown fall in 23% of the area and rise in 77% of the area. Maximum rise of 22.4 m in Prakasamt district and maximum fall of 26.8 m is also in Prakasam district.

Water level fluctuation of Nov, 2017 with pre-monsoon water level of May, 2017 have shown fall in 9% of the area and rise in 91% of the area. Maximum rise of 18.6 m is in Prakasam district and maximum fall is 15.7 m in Krishna distirct.

Water level fluctuation of Jan, 2018 with pre-monsoon water level of May, 2017 have shown fall in 10% of the area and rise in 90% of the area. Maximum rise of 28.6 m in Anantapuramu district and maximum fall is 24.7 m in Prakasam distirct

Annual water level fluctuation during May, 2017 from May, 2016 has shown fall in water levels in 63% of the area and rise in 28% of the area. Maximum rise of 28.1 m is observed in Guntur district and maximum fall is noticed in Visakhapatnam district (42.6 m).

Annual water level fluctuation during Aug, 2017 from Aug, 2016 has shown fall in water levels in 54% of the area and rise in 42% of the area. Maximum fall is noticed in Prakasam district (27.1 m) and miminim rise of 22.4 m is observed in Prakasam districts.

Annual water level fluctuation during Nov-2017 from Nov,2016 has shown fall in water levels in 39 % of the area and rise in 59% of the area. The maximum rise of 22.1 m is recorded in Prakasam district and maximum fall of 20.2 m is recorded in Guntur district.

Annual water level fluctuation during January-2018 from January-17 has shown fall in water levels in 39 % of the area and rise in 61% of the area. The maximum rise of 53.8 m recorded in YSR Kadapa district and the maximum fall of 31.1 m is recorded in Prakasam district

Water levels during May-17, August-17, November-17 and January-18 as compared to decadal mean water levels, have shown fall in most of the wells as well as in most of the area with an exception of Jan 18 water level which have a shown rise in Rayalaseema districts in comparison with decadal mean of Jan water levels. The percentage of wells with fall in water levels in comparison with decadal mean of the respective months is 75%, 59%, 53% and 55% in May-17, August-17, November-17 and January-18 respectively.

Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in all the formations except Intrusives. Deepest water levels are observed Alluvium, Limestone and BGC. During post-monsoon season, shallowest water leves are observd in all formations except in Intrusives and Laterites. Deepest water levels are observed in Gniess, Granite, Limestone, Quartz and Sansstone.

Based on long term water level trend maps, it is inferred that, during pre-monsoon season, rise in water level trend is observed in 40% of the area, fall in trend is observed in 60% of the area. During post-monsoon season, rise in water level trend is observed in 42% of the area, fall in trend is observed in 58% of the area. Based on annual trend, rise in water levels during the twenty period(1998-2017) , is observed in 19% of the area and rise is observed in 81% of the area.

Ground water quality is assessed during pre-monsoon season of 2017 by collecting 600 samples from both dug wells and peizometers and 14 parameters namely pH, EC (in µS/cm at 25 ° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3, F and TDS were analyzed as per standard guidelines laid down in APHA and suitability of ground water for drinking purposes is assessed as per BIS guidelines and for irrigation as per USSL and RSC.

Groundwater from the state is slightly acidic to alkaline in nature with pH in the range of 6.15 to 8.88. Electrical conductivity varies from 125-21560 µ Siemens/cm. Total Dissolved Solids (TDS) varies from 72-12323 mg/l and in 68 samples it is beyond 2000 mg/l (11.3 %). Total hardness varies from 40-4300 mg/l and in 19 % of samples it is beyond 600 mg/l. Calcium and magnesium varies from 4 to 661 mg/l (in 6 % samples it is beyond permissible limits of BIS i.e., >200 mg/l) and 1.3 to 644 mg/l (in Krishna district it is beyond permissible limits of BIS i.e., >100 mg/l). Sodium and potassium varies from 5 - 3094 mg/L and BDL (Below detection Limit) to 860 mg/l respectively. The HCO_3 concentration varies from 18 to 1305 mg/l. Chloride and sulphate varies from 11 to 7374 mg/l and 16 to 2957 mg/l respectively in 4% of samples. NO_3 ranges from 0 to 959 mg/l and found that 35 % samples are unfit for human consumption (>45 mg/l). Fluoride concentration varies from 0.09 to 3.82 mg/l (Reddigudem of Krishna district) and found that 7% samples are unfit for human consumption (beyond 1.5 mg/l).

As far as irrigation suitability of ground water is concerned it is found that majority of samples fall in C_3S_1 type of water. As per RSC classification of waters only 12 % are unfit for irrigation. Ground water from the area is mainly of Na-Mg-HCO_3-Cl and Na-HCO_3-Cl type followed by Na-Mg-Cl-HCO_3 and Ca-Na-HCO_3-Cl type.

ANNEXURE-I DISTRICT-WISE STATUS OF GROUND WATER MONITORING WELLS – MAY 2017, ANDHRA PRADESH																				
District	**No of Stations to be monitored**			**No of Stations where WL data Recorded**			**No of Stations Monitored as Dry**			**No of Stations not Monitored due to Various Reasons**			**No of Stations Abandoned**			**No of Stations Established**			**No of Stations as on May 2017**		
	DW	**Pz**	**Total**	**DW**	**Pz**	**Total**	**DW**	**Pz**	**Total**	**DW**	**Pz**	**Total**	**DW**	**Pz**	**Total**	**DW**	**Pz**	**Total**	**DW**	**Pz**	**Total**
Anantapur	36	20	56	24	19	43	10	1	11	2	0	2	0	0	0	0	0	0	36	20	56
Chittoor	48	0	48	34	0	34	14	0	14	0	0	0	0	0	0	0	0	0	48	0	48
Cuddapah	28	13	41	17	10	27	11	3	14	0	0	0	0	0	0	0	0	0	28	13	41
East Godavari	94	13	107	84	9	93	6	2	8	6	3	9	4	0	4	0	0	0	90	13	103
Guntur	85	13	98	77	9	86	8	1	9	0	3	3	0	0	0	0	0	0	85	13	98
Krishna	69	7	76	56	4	60	11	0	11	2	3	5	1	0	1	0	0	0	68	7	75
Kurnool	39	19	58	28	13	41	11	0	11	0	6	6	0	0	0	0	0	0	39	19	58
Nellore	59	1	60	26	1	27	29	0	29	4	0	4	0	0	0	0	0	0	59	1	60
Prakasam	52	14	67	31	9	40	20	1	21	4	0	4	0	0	0	0	0	0	52	14	66
Srikakulam	54	0	54	51	0	51	3	0	3	0	0	0	0	0	0	0	0	0	54	0	54
Visakhapatnam	**67**	**4**	71	62	3	65	**4**	**1**	5	**0**	**0**	0	**1**	0	1	**0**	0	0	66	4	70
Vizianagaram	**51**	**0**	51	48	0	48	**2**	**0**	2	**0**	**0**	0	**1**	0	1	0	0	0	50	0	50
West Godavari	**60**	**9**	69	44	7	51	**5**	**0**	5	**9**	**2**	11	**5**	0	5	**0**	0	0	55	9	64
Total	**742**	**113**	**855**	**582**	**84**	**666**	**134**	**9**	**143**	**27**	**17**	**44**	**13**	**0**	**13**	**0**	**0**	**0**	**730**	**113**	**843**

ANNEXURE II - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- AUG, 2017

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on Aug 2017		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	36	20	56	26	31	57	9	1	10	1	1	2	0	0	0	0	13	13	36	33	69
2	Chittoor	48	0	48	37	0	37	7	0	7	4	0	4	0	0	0	0	0	0	48	0	48
3	Cuddapah	28	13	41	16	18	34	11	7	18	1	1	2	0	0	0	0	13	13	28	26	54
4	East Godavari	90	13	103	84	11	95	1	0	1	6	1	7	3	1	4	0	0	0	87	12	98
5	Guntur	85	13	98	82	9	91	2	0	2	1	4	5	0	0	0	0	0	0	85	13	98
6	Krishna	68	7	75	62	3	65	5	0	5	1	4	5	0	0	0	0	0	0	68	7	75
7	Kurnool	39	19	58	29	18	47	8	1	9	0	0	0	2	0	2	1	0	1	38	19	57
8	Nellore	59	1	60	40	0	40	15	1	16	4	0	4	0	0	0	0	0	0	59	1	60
9	Prakasam	52	14	66	30	10	40	18	2	20	2	2	4	2	0	2	0	0	0	50	14	64
10	Srikakulam	54	0	54	53	0	53	0	0	0	0	0	0	1	0	1	0	0	0	53	0	53
11	Visakhapatnam	**66**	**4**	70	62	3	65	**0**	**0**	0	**1**	**0**	1	**3**	1	4	0	0	0	63	3	66
12	Vizianagaram	**50**	**0**	50	50	0	50	**0**	**0**	0	**0**	**0**	0	**0**	0	0	0	0	0	50	0	50
13	West Godavari	**55**	**9**	64	52	9	61	**0**	**0**	0	**2**	**0**	2	**1**	0	1	0	0	0	54	9	63
	Total	**730**	**113**	**843**	**623**	**112**	**735**	**76**	**12**	**88**	**23**	**13**	**36**	**12**	**2**	**14**	**1**	**26**	**27**	**719**	**137**	**856**

ANNEXURE III - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- NOV, 2017

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on Nov 2017		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	36	33	69	32	30	62	3	0	3	0	3	3	1	0	1	0	0	0	35	33	68
2	Chittoor	48	0	48	42	0	42	4	0	4	1	0	1	0	0	0	0	0	0	48	0	48
3	Cuddapah	28	26	54	28	24	52	0	1	1	0	1	1	0	0	0	0	0	0	28	26	54
4	East Godavari	87	12	99	85	12	97	0	0	0	1	0	1	0	0	0	0	0	0	87	12	99
5	Guntur	85	13	98	76	13	89	0	0	0	9	0	9	0	0	0	0	0	0	85	13	98
6	Krishna	68	7	75	63	4	67	4	0	4	0	3	3	1	0	1	0	0	0	67	7	74
7	Kurnool	38	19	57	36	20	56	1	0	1	0	0	0	0	0	0	0	0	0	38	19	57
8	Nellore	59	1	60	46	0	46	3	0	3	10	0	10	0	0	0	0	0	0	59	1	60
9	Prakasam	50	14	64	42	13	55	7	0	7	1	1	2	0	0	0	0	0	0	50	14	64
10	Srikakulam	53	0	53	52	0	52	0	0	0	1	0	1	1	0	1	1	0	1	53	0	53
11	Visakhapatnam	63	3	66	61	3	64			0			0	**0**	0	0	0	0	0	63	3	66
12	Vizianagaram	50	0	50	49	0	49	**0**	**0**	0	**1**	**0**	1	**0**	0	0	1	0	1	51	0	51
13	West Godavari	54	9	63	54	8	62	**1**	**0**	1	**2**	**1**	3	**0**	0	0	0	0	0	54	9	63
	Total	**719**	**137**	**856**	**666**	**127**	**793**	**23**	**1**	**24**	**26**	**9**	**35**	**3**	**0**	**3**	**2**	**0**	**2**	**718**	**137**	**855**

ANNEXURE IV - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- JAN, 2018

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on Jan, 2018		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	35	33	68	30	32	62	2	0	2	3	1	4	0	0	0	0	0	0	35	33	68
2	Chittoor	48	0	48	42	0	42	4	0	4	2	0	2	0	0	0	0	10	10	48	10	58
3	Cuddapah	28	26	54	27	24	51	1	1	2	0	1	1	0	0	0	0	0	0	28	26	54
4	East Godavari	87	12	99	82	12	94	0	0	0	5	0	5	0	0	0	0	0	0	87	12	99
5	Guntur	85	13	98	83	10	93	2	1	3	0	2	2	0	0	0	0	0	0	85	13	98
6	Krishna	67	7	74	60	6	66	4	0	4	3	1	4	0	0	0	0	0	0	67	7	74
7	Kurnool	38	19	57	37	20	57	2	0	2	0	2	2	0	0	0	0	0	0	38	19	57
8	Nellore	59	1	60	53	1	54	4	0	4	2	0	2	0	0	0	0	0	0	59	1	60
9	Prakasam	50	14	64	35	9	44	14	3	17	1	2	3	0	0	0	0	0	0	50	14	64
10	Srikakulam	53	0	53	52	0	52	0	0	0	2	0	2	0	0	0	0	0	0	53	0	53
11	Visakhapatnam	63	3	66	57	3	60	**1**	**0**	1	**5**	**0**	5	**0**	0	0	0	0	0	63	3	66
12	Vizianagaram	51	0	51	49	0	49	**0**	**0**	0	**2**	**0**	2	**0**	0	0	0	0	0	51	0	51
13	West Godavari	54	9	63	54	8	62	**3**	**0**	3	**1**	**1**	2	**0**	0	0	0	0	0	54	9	63
	Total	**718**	**137**	**855**	**661**	**125**	**786**	**37**	**5**	**42**	**26**	**10**	**36**	**0**	**0**	**0**	**0**	**10**	**10**	**718**	**147**	**865**
		Note: Well could not be measured due to root obstruction, non-approachability, filled up and blockage due to other material.																				

ANNEXURE V - DISTRIBUTION OF PERCENTAGE OF WELLS , MAY, 2017 (m bgl).

Sl. No	District	No of wells analysed	Depth to Water level (m bgl)		No and Percentage of wells showing depth to water level (m bgl) in Range of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	41	0.9	19.84	4	10	4	10	16	39	17	41	0	0	0	0
2	Chittoor	48	1.72	18.15	1	2	12	25	21	44	14	29	0	0	0	0
3	YSR Kadapa	30	3.42	47.45	0	0	3	10	17	57	8	26	1	3	1	3
4	East Godavari	85	1.21	10	10	12	45	53	30	35	0	0	0	0	0	0
5	Guntur	94	0.28	39.5	12	13	38	40	35	37	8	8	1	1	0	0
6	Krishna	70	-0.25	21.67	4	5	36	51	19	27	10	14	1	1	0	0
7	Kurnool	46	0.55	18.63	3	6	9	20	23	50	11	24	0	0	0	0
8	Nellore	56	2.07	17	0	0	17	30	24	42	15	27	0	0	0	0
9	Prakasham	61	2.56	49.3	0	0	17	28	27	44	16	26	0	0	1	2
10	Srikakulam	50	2.19	13.2	0	0	20	40	27	44	3	6	0	0	0	0
11	Visakhapatnam	70	0.91	45.2	7	10	29	41	26	37	6	8	1	1	1	1
12	Vizianagaram	50	2.08	12.1	0	0	21	42	26	52	3	6	0	0	0	0
13	West Godavari	50	1.7	17.5	5	10	27	54	14	28	4	8	0	0	0	0
Total State		751	-0.25	49.3	46		278		305		115		4		3	

ANNEXURE VI - DISTRIBUTION OF PERCENTAGE OF WELLS, AUG, 2017 (m bgl).

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	45	0.91	25.5	5	11	4	9	14	31	21	47	1	2	0	0
2	Chittoor	44	0.98	15.75	4	9	12	27	18	41	10	23	0	0	0	0
3	YSR Kadapa	30	2.25	47.45	0	0	4	13	17	57	7	23	1	3	1	3
4	East Godavari	86	0.27	9.08	42	49	33	38	11	13	0	0	0	0	0	0
5	Guntur	93	-0.36	19.84	25	27	44	47	20	22	4	4	0	0	0	0
6	Krishna	70	0.09	21.79	29	41	23	33	11	16	6	8	1	1	0	0
7	Kurnool	48	0.1	22	11	23	10	21	18	37	8	17	1	2	0	0
8	Nellore	55	1.28	21.4	4	7	19	35	22	40	9	16	1	2	0	0
9	Prakasham	60	0.5	31.2	2	3	15	25	27	45	12	20	4	7	0	0
10	Srikakulam	49	0.21	6.04	28	57	15	30	6	12	0	0	0	0	0	0
11	Visakhapatnam	63	0.12	29	29	46	18	29	11	17	4	6	1	2	0	0
12	Vizianagaram	50	0.47	10.58	17	34	24	48	8	16	1	2	0	0	0	0
13	West Godavari	52	0.15	10.34	33	63	10	19	8	15	1	2	0	0	0	0
Total State		745	-0.36	47.45	229		231		191		83		10		1	

ANNEXURE VII - DISTRIBUTION OF PERCENTAGE OF WELLS, NOV, 2017 (m bgl).

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	44	0.21	20.99	11	25	14	32	10	23	8	18	1	2	0	0
2	Chittoor	46	-0.18	14.6	14	30	16	35	13	29	3	7	0	0	0	0
3	YSR Kadapa	29	0.8	9.63	9	31	9	31	11	38	0	0	0	0	0	0
4	East Godavari	94	0.34	9.6	52	55	36	38	6	6	0	0	0	0	0	0
5	Guntur	96	0.27	39.5	31	32	43	45	17	18	4	4	1	1	0	0
6	Krishna	69	-0.8	21.5	33	48	21	30	8	12	6	8	1	1	0	0
7	Kurnool	48	-0.3	12.26	19	40	18	38	9	19	2	4	0	0	0	0
8	Nellore	49	0.36	12.12	19	39	18	37	10	21	2	4	0	0	0	0
9	Prakasham	62	0.94	30.72	6	10	23	37	26	42	6	10	1	2	0	0
10	Srikakulam	48	0.31	8.16	29	60	17	35	2	4	0	0	0	0	0	0
11	Visakhapatnam	64	0.23	28.8	26	40	21	32	15	23	1	2	1	2	0	0
12	Vizianagaram	49	0.64	10.74	24	49	22	45	2	4	1	2	0	0	0	0
13	West Godavari	53	0.6	17.5	28	53	14	26	9	17	2	4	0	0	0	0
Total State		751	-0.8	39.5	301		272		138		35		5		0	0

ANNEXURE VIII - DISTRIBUTION OF PERCENTAGE OF WELLS, JAN, 2018 (m bgl).

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	0 TO 2	% OF WELLS	2 TO 5	% OF WELLS	5 TO 10	% OF WELLS	10 TO 20	% OF WELLS	20 TO 40	% OF WELLS	> 40	% OF WELLS
1	SRIKAKULAM	49	0.90	7.00	3.10	13	27%	31	63%	5	10%	0	0%	0	0%	0	0%
2	VIZIANAGARAM	49	0.95	11.80	4.00	5	10%	33	67%	10	20%	1	2%	0	0%	0	0%
3	VISAKHAPATNAM	60	0.46	30.50	4.80	16	27%	24	40%	15	25%	4	7%	1	2%	0	0%
4	EAST GODAVARI	94	0.47	17.97	3.63	28	30%	48	51%	13	14%	5	5%	0	0%	0	0%
5	WEST GODAVARI	61	0.76	41.55	5.25	18	30%	22	36%	17	28%	2	3%	1	2%	1	2%
6	KRISHNA	71	0.72	29.30	5.25	20	28%	30	42%	12	17%	6	8%	3	4%	0	0%
7	GUNTUR	95	0.28	39.50	4.01	23	24%	53	56%	15	16%	3	3%	1	1%	0	0%
8	PRAKASAM	61	0.94	69.50	9.16	4	7%	18	30%	25	41%	10	16%	2	3%	2	3%
9	NELLORE	58	-0.07	14.50	3.83	21	36%	25	43%	8	14%	4	7%	0	0%	0	0%
10	CHITTOOR	54	0.57	46.02	5.79	10	19%	23	43%	16	30%	4	7%	0	0%	1	2%
11	KADAPA	53	0.72	99.50	9.73	8	15%	12	23%	20	38%	9	17%	2	4%	2	4%
12	ANANTAPUR	65	0.39	104.40	11.78	10	15%	19	29%	12	18%	18	28%	3	5%	3	5%
13	KURNOOL	55	0.02	40.26	5.09	14	25%	22	40%	15	27%	3	5%	0	0%	1	2%
	STATE FIGIURES	**825**	**-0.07**	**104.40**	**5.7**	**190**	**23%**	**360**	**44%**	**183**	**22%**	**69**	**8%**	**13**	**2%**	**10**	**1.2%**

ANNEXURE IX - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2017 FROM MAY, 2017

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.05	4.53	0.01	8.21	13	32	5	12	2	5	10	25	0	0	2	5	20	12
2	Chittoor	44	0.01	6.52	0.03	1.79	19	43	7	16	2	5	9	20	0	0	0	0	28	9
3	YSR Kadapa	30	0.05	5.05	0.04	1.9	8	27	1	3	1	3	9	30	0	0	0	0	10	9
4	East Godavari	81	0.1	7.54	0.09	1.43	52	64	14	17	9	11	4	5	0	0	0	0	75	4
5	Guntur	92	0.13	19.66	0.14	2.72	60	65	16	17	3	3	8	9	3	3	0	0	79	11
6	Krishna	70	0.15	12.9	0.06	2.39	36	51	18	26	5	7	5	7	1	1	0	0	59	6
7	Kurnool	45	0.01	7.98	0.05	3.6	16	36	8	18	5	11	7	15	2	4	0	0	29	9
8	Nellore	51	0.29	9.36	0.1	16.78	15	29	6	12	6	12	7	14	0	0	2	4	27	9
9	Prakasham	57	0.01	22.4	0.1	26.78	22	39	3	5	2	3	9	15	1	2	5	8	27	15
10	Srikakulam	49	0.44	10.35	0.04	0.04	7	14	19	39	22	45	1	2	0	0	0	0	48	1
11	Visakhapatnam	63	0.04	7.72	0.03	0.75	31	49	22	35	8	13	2	3	0	0	0	0	61	2
12	Vizianagaram	50	0.04	6.94	0.88	1.19	15	30	22	44	11	22	2	4	0	0	0	0	48	2
13	West Godavari	49	0.29	14.18	0.01	0.01	33	67	10	20	5	10	1	2	0	0	0	0	48	1
Total State		722	0.01	22.4	0.01	26.78	327		151		81		74		7		9		559	90

ANNEXURE X - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2017 FROM MAY, 2017

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.08	12.48	2.03	4.75	9	23	6	15	19	48	0	0	1	3	2	5	34	3
2	Chittoor	46	0.15	12.72	1.27	7.91	11	24	8	18	21	45	1	2	1	2	3	7	40	5
3	YSR Kadapa	29	1	12.9		_	4	14	8	28	17	59	0	0	0	0	0	0	29	0
4	East Godavari	84	0.04	7.57	0.01	1.2	45	54	19	23	16	19	4	5	0	0	0	0	80	4
5	Guntur	92	0.02	10.37	0.01	8.77	49	53	21	23	11	12	6	7	3	3	1	1	81	10
6	Krishna	68	0.17	13.93	0.02	15.7	33	49	19	28	7	10	3	5	1	2	1	2	59	5
7	Kurnool	44	0.15	12.22	0.1	0.1	11	25	14	32	17	39	1	2	0	0	0	0	42	1
8	Nellore	46	0.04	19.18	0.63	0.63	12	26	12	26	18	39	1	2	0	0	0	0	42	1
9	Prakasham	59	0.1	18.58	0.03	4.32	26	44	12	20	6	10	8	14	0	0	1	2	44	9
10	Srikakulam	47	0.65	9.24	4.76	4.76	8	17	17	36	21	45	0	0	0	0	1	2	46	1
11	Visakhapatnam	64	0.15	7.6	0.52	4.9	28	44	26	41	6	10	2	3	1	2	1	2	60	4
12	Vizianagaram	48	0.81	8.24	2.84	2.84	7	15	18	38	22	45	0	0	1	2	0	0	47	1
13	West Godavari	49	0.09	9.12	0.09	0.55	32	65	5	10	9	19	2	4	0	0	0	0	46	2
Total State		716	0.02	19.18	0.01	15.7	275		185		190		28		8		10		650	46

ANNEXURE XI - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2018 FROM MAY, 2017

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	51	2	4%	-2.36	-0.01	-1.19	1	50%	1	50%	0	0%	49	96%	0.01	28.60	5.16	10	20%	19	39%	20	41%
2	CHITTOOR	46	3	7%	-4.55	-0.74	-2.35	2	67%	0	0%	1	33%	43	93%	0.01	13.55	3.86	17	40%	13	30%	13	30%
3	KADAPA	38	1	3%	-1.49	-1.49	-1.49	1	100%	0	0%	0	0%	37	97%	0.01	26.09	5.98	9	24%	11	30%	17	46%
4	EAST GODAVARI	84	9	11%	-4.50	-1.49	-1.30	7	78%	1	11%	1	11%	75	89%	0.05	6.71	1.65	54	72%	19	25%	2	3%
5	GUNTUR	91	14	15%	-7.16	-0.08	-1.01	13	93%	0	0%	1	7%	77	85%	0.01	10.77	1.94	43	56%	32	42%	2	3%
6	KRISHNA	68	6	9%	-15.70	-0.07	-3.36	4	67%	1	17%	1	17%	62	91%	0.01	14.02	1.78	48	77%	9	15%	5	8%
7	KURNOOL	51	4	8%	-6.70	-0.01	-3.28	2	50%	0	0%	2	50%	47	92%	0.01	18.82	4.35	16	34%	15	32%	16	34%
8	NELLORE	54	3	6%	-2.85	-0.20	-1.66	2	67%	1	33%	0	0%	51	94%	0.01	11.35	3.60	20	39%	17	33%	14	27%
9	PRAKASAM	57	11	19%	-27.66	-0.11	-7.60	4	36%	1	9%	6	55%	46	81%	0.01	7.22	1.37	35	76%	8	17%	3	7%
10	SRIKAKULAM	48	1	2%	-0.05	-0.05	-0.05	1	100%	0	0%	0	0%	47	98%	0.30	8.55	3.12	12	26%	28	60%	7	15%
11	VISAKHAPATNAM	60	8	13%	-6.20	-0.05	-1.25	6	75%	1	13%	1	13%	52	87%	0.01	7.00	1.35	44	85%	7	13%	1	2%
12	VIZIANAGARAM	49	4	8%	-0.94	-0.10	-0.38	4	100%	0	0%	0	0%	45	92%	0.07	6.03	2.31	17	38%	27	60%	1	2%
13	WEST GODAVARI	55	10	18%	-1.45	-0.12	-0.70	10	100%	0	0%	0	0%	45	82%	0.01	7.19	1.45	35	78%	8	18%	2	4%
	STATE FIGIURES	752	76	10%	-27.66	-0.01	-2.06	57	75%	6	8%	13	17%	676	90%	0.01	28.60	2.40	360	53%	213	32%	103	15%

ANNEXURE XII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER MAY, 2017 FROM MAY, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.49	3.16	0.25	7.29	4	10	2	4	0	0	12	29	13	32	6	15	6	31
2	Chittoor	47	0.70	7.91	0.10	13.25	3	6	0	0	1	2	18	38	13	28	11	23	4	42
3	YSR Kadapa	30	0.10	5.10	0.05	42	4	13	0	0	3	10	9	30	5	16	4	13	7	18
4	East Godavari	85	0.01	2.27	0.02	5.26	32	37	2	2	0	0	39	46	5	6	3	3	34	47
5	Guntur	94	0.02	28.10	0.04	2.44	37	39	8	9	5	5	35	37	3	3	0	0	50	38
6	Krishna	69	0.07	15.70	0.01	12.87	22	31	6	8	1	1	25	36	3	4	2	3	29	30
7	Kurnool	46	0.10	8.10	0.15	5.90	12	26	1	2	5	11	14	30	3	6	2	4	18	19
8	Nellore	55	1.36	4.24	0.08	12.30	1	2	0	0	1	2	20	36	14	25	17	30	2	51
9	Prakasham	60	0.16	19.18	0.28	6.92	10	16	4	6	5	8	16	27	10	16	4	6	19	30
10	Srikakulam	48	0.02	5.14	0.10	5.40	9	18	0	0	2	4	28	58	7	15	1	2	11	36
11	Visakhapatnam	67	0.03	2.35	0.01	42.60	10	15	1	1	0	0	38	57	11	16	5	7	11	54
12	Vizianagaram	49	0.07	4.04	0.02	4.55	8	16	0	0	1	2	32	65	6	12	2	4	9	40
13	West Godavari	50	0.01	7.40	0.07	5.36	14	28	1	2	1	2	27	54	0	0	2	4	16	29
Total State		741	1.36	28.10	0.01	42.60	166		25		25		313		93		59		216	465

ANNEXURE XIII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2017 FROM AUG, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	42	0.84	0.91	0.05	8.24	2	5	0	0	0	0	19	45	8	19	10	24	2	37
2	Chittoor	43	0.05	1.06	0.01	9.46	9	21	0	0	0	0	14	33	8	19	10	24	9	32
3	YSR Kadapa	29	0.30	3.60	0.15	7.64	4	14	2	7	0	0	6	21	7	24	5	17	6	18
4	East Godavari	86	0.05	2.83	0.01	7.00	22	26	1	1	0	0	50	58	7	8	5	6	23	62
5	Guntur	89	0.06	19.66	0.03	5.45	37	42	15	17	10	11	23	26	2	2	1	1	62	26
6	Krishna	69	0.01	16.11	0.02	9.98	30	44	7	10	1	1	21	30	3	4	3	4	38	27
7	Kurnool	44	0.01	7.00	0.14	9.14	8	18	3	7	1	2	15	34	11	25	3	7	12	29
8	Nellore	54	0.03	3.68	0.03	17.40	12	22	3	6	0	0	25	46	7	13	7	13	15	39
9	Prakasham	59	0.15	22.40	0.09	27.10	13	22	3	5	3	5	15	25	12	20	4	7	19	31
10	Srikakulam	45	0.07	5.11	0.04	2.70	28	62	9	20	2	4	4	9	2	4	0	0	39	6
11	Visakhapatnam	60	0.05	4.30	0.05	4.30	34	57	1	2	1	2	16	27	5	8	2	3	36	23
12	Vizianagaram	49	0.12	3.46	0.05	7.42	17	35	4	8	0	0	21	43	4	8	3	6	21	28
13	West Godavari	52	0.03	3.20	0.02	3.14	16	31	3	5	0	0	31	60	1	2	0	0	19	32
Total State		721	0.01	22.40	0.01	27.10	232		51		18		260		77		53		301	390

ANNEXURE XIV - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2017 FROM NOV, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.10	0.18	0.26	16.08	13	32	8	20	12	29	2	5	2	5	3	7	33	7
2	Chittoor	45	0.37	10.38	0.28	7.67	17	38	8	18	9	20	5	11	2	5	4	9	34	11
3	YSR Kadapa	29	0.25	12.90	0.01	1.15	8	28	7	24	11	38	3	10	0	0	0	0	26	3
4	East Godavari	92	0.03	5.98	0.01	4.49	34	37	3	4	1	1	52	56	1	1	1	1	38	54
5	Guntur	92	0.03	10.37	0.01	20.20	46	50	3	4	3	3	29	32	5	6	6	7	52	40
6	Krishna	68	0.01	1.87	0.02	13.75	21	31	0	0	0	0	36	52	6	9	2	3	21	44
7	Kurnool	45	0.10	14.30	0.12	4.88	18	40	13	29	3	6	9	20	0	0	1	2	34	10
8	Nellore	45	0.01	6.76	0.04	2.86	18	40	6	14	8	18	7	16	4	9	0	0	32	11
9	Prakasham	58	0.09	22.14	0.01	4.04	17	29	4	6	5	8	16	28	9	16	1	2	26	26
10	Srikakulam	47	0.05	4.46	0.12	4.29	31	66	2	4	2	4	8	17	2	5	2	4	35	12
11	Visakhapatnam	64	0.01	3.65	0.09	6.42	36	56	1	2	0	0	19	30	3	5	4	6	37	26
12	Vizianagaram	48	0.05	3.97	0.24	3.26	33	69	6	12	0	0	8	16	1	2	0	0	39	9
13	West Godavari	53	0.03	4.65	0.04	5.35	19	36	1	2	2	4	27	51	2	4	2	4	22	31
Total State		727	0.01	22.14	0.01	20.20	311		62		56		221		37		26		429	284

ANNEXURE XV - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2018 FROM JAN, 2017

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	53	5	9%	-0.55	-0.12	-0.24	5	100%	0	0%	0	0%	48	91%	0.01	9.89	3.57	12	25%	23	48%	13	27%
2	CHITTOOR	46	10	22%	-5.85	-0.02	-1.36	8	80%	1	10%	1	10%	36	78%	0.01	8.65	2.21	19	53%	12	33%	5	14%
3	KADAPA	38	5	13%	-3.10	-0.42	-1.14	4	80%	1	20%	0	0%	33	87%	0.01	53.79	4.85	12	36%	13	39%	8	24%
4	EAST GODAVARI	92	51	55%	-4.98	-0.42	-0.92	43	84%	7	14%	1	2%	41	45%	0.01	16.85	1.31	35	85%	4	10%	2	5%
5	GUNTUR	88	33	38%	-14.32	-0.06	-1.20	30	91%	1	3%	2	6%	55	63%	0.01	4.57	0.78	50	91%	5	9%	0	0%
6	KRISHNA	70	42	60%	-3.09	-0.02	-0.60	39	93%	3	7%	0	0%	28	40%	0.01	2.02	0.29	27	96%	1	4%	0	0%
7	KURNOOL	54	13	24%	-8.24	-0.04	-2.19	10	77%	0	0%	3	23%	41	76%	0.01	29.66	2.87	23	56%	13	32%	5	12%
8	NELLORE	57	16	28%	-5.78	-0.01	-1.02	12	75%	3	19%	1	6%	41	72%	0.01	6.63	1.69	30	73%	10	24%	1	2%
9	PRAKASAM	55	24	44%	-31.10	-0.03	-3.90	16	67%	2	8%	6	25%	31	56%	0.01	5.97	1.65	21	68%	7	23%	3	10%
10	SRIKAKULAM	48	14	29%	-1.21	-0.05	-0.38	14	100%	0	0%	0	0%	34	71%	0.01	5.65	1.21	29	85%	4	12%	1	3%
11	VISAKHAPATNAM	60	32	53%	-7.12	-0.04	-1.18	26	81%	4	13%	2	6%	28	47%	0.01	4.85	0.68	27	96%	1	4%	0	0%
12	VIZIANAGARAM	49	22	45%	-2.52	-0.22	-1.09	20	91%	2	9%	0	0%	27	55%	0.01	2.64	0.66	26	96%	1	4%	0	0%
13	WEST GODAVARI	60	37	62%	-5.79	-0.02	-0.89	33	89%	3	8%	1	3%	23	38%	0.01	5.24	0.92	20	87%	2	9%	1	4%
	STATE FIGIURES	770	**304**	**39%**	**-31.10**	**-0.01**	**-0.90**	**260**	**86%**	**27**	**9%**	**17**	**6%**	**466**	**61%**	**0.01**	**53.79**	**1.71**	**331**	71%	**96**	**21%**	**39**	**8%**

ANNEXURE XVI - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER MAY, 2017 FROM DECADAL MEAN OF MAY(2007-16)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.21	5.19	0.19	9.47	7	17	0	0	1	2	15	36	13	31	5	12	8	33
2	Chittoor	48	0.02	7.91	0.16	6.11	11	23	5	10	2	4	21	43	7	15	2	4	18	30
3	YSR Kadapa	30	0.11	2.93	0.24	30.77	4	13	2	6	0	0	15	50	4	13	3	10	6	22
4	East Godavari	85	0.02	2.05	0.04	4.62	21	25	1	1	0	0	52	61	8	10	3	3	22	63
5	Guntur	94	0.03	6.93	0.04	6.13	24	25	4	4	1	1	45	47	15	15	5	5	29	65
6	Krishna	70	0.01	3	0.08	10.79	18	26	1	1	0	0	42	60	2	3	7	10	19	51
7	Kurnool	46	0.05	4.55	0.2	5.93	13	28	0	0	2	4	16	34	9	19	6	13	15	31
8	Nellore	56	0.54	4.67	0.14	9.62	5	9	0	0	1	2	21	37	16	28	13	23	6	50
9	Prakasham	61	0.04	11.25	0.14	10.27	5	8	1	2	3	4	32	52	12	19	8	13	9	52
10	Srikakulam	50	0.02	4.21	0.1	5.08	12	24	1	2	1	2	29	58	5	10	2	4	14	36
11	Visakhapatnam	70	0.02	2.64	0.01	42.38	19	27	1	1	0	0	40	57	7	10	3	4	20	50
12	Vizianagaram	50	0.04	1.98	0.03	4.31	9	18	0	0	0	0	34	68	5	10	2	4	9	41
13	West Godavari	50	0.07	7.4	0.05	6.44	8	16	1	2	1	2	33	66	3	6	2	4	10	38
Total State		751	0.01	11.25	0.01	42.38	156		17		12		395		106		61		185	562

ANNEXURE XVII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2017 FROM DECADAL MEAN OF AUG(2007-16)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	42	0.02	2.57	0.08	9.56	8	19	1	2	0	0	13	31	14	33	5	12	9	32
2	Chittoor	44	0.01	7.25	0.24	3.44	16	36	3	7	4	9	13	30	7	16	0	0	23	20
3	YSR Kadapa	30	0.13	3.22	0.06	25.04	7	23	2	7	0	0	9	30	7	23	4	13	9	20
4	East Godavari	86	0.01	1.87	0.02	6.42	29	34	0	0	0	0	47	55	7	8	3	3	29	57
5	Guntur	93	0.09	19.66	0.01	5.96	36	39	6	6	1	1	36	39	10	11	4	4	43	50
6	Krishna	70	0.06	2.98	0.02	8.22	30	43	2	3	0	0	27	39	7	10	4	6	32	38
7	Kurnool	48	0.11	3.9	0.15	8.38	13	27	6	13	0	0	13	27	11	23	5	11	19	29
8	Nellore	55	0.05	3.29	0.05	15.75	12	22	2	4	0	0	25	45	9	16	7	13	14	41
9	Prakasham	60	0.03	8.91	0.05	27.33	11	18	2	3	1	2	24	40	12	20	9	15	14	45
10	Srikakulam	45	0.01	3.67	0.01	3.82	23	51	5	11	0	0	14	31	3	7	0	0	28	17
11	Visakhapatnam	63	0.01	3.6	0.02	8.1	36	57	3	5	0	0	17	27	5	8	2	3	39	24
12	Vizianagaram	49	0.05	1.37	0.09	4.33	16	33	0	0	0	0	24	49	8	16	1	2	16	33
13	West Godavari	52	0.02	2.91	0.01	3.59	19	37	2	4	0	0	29	56	2	4	0	0	21	31
Total State		737	0.01	19.66	0.01	27.33	256		34		6		291		102		44		296	437

ANNEXURE XVIII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2017 FROM DECADAL MEAN OF NOV(2007-16)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.3	7.71	0.18	12.77	15	37	8	20	2	5	7	17	4	10	5	12	25	16
2	Chittoor	46	0.09	9.57	0.19	8.19	10	22	11	25	13	28	6	13	4	9	2	4	34	12
3	YSR Kadapa	29	0.08	5.41	0.16	1.78	10	34	9	31	5	17	5	17	0	0	0	0	24	5
4	East Godavari	94	0	4.51	0	4.58	40	42	2	2	1	1	50	53	0	0	1	1	43	51
5	Guntur	96	0.02	3.11	0.01	22.96	37	39	2	2	0	0	38	40	11	12	8	8	39	57
6	Krishna	69	0	2.28	0.01	15.78	25	36	1	1	0	0	31	45	7	10	5	7	26	43
7	Kurnool	47	0.01	7.75	0.03	3.89	21	45	9	19	2	4	10	21	4	9	0	0	32	14
8	Nellore	49	0.13	5.76	0.02	3.45	18	37	6	12	2	4	18	37	5	10	0	0	26	23
9	Prakasham	61	0.01	13.15	0.06	5.28	11	19	3	5	1	2	28	46	13	21	5	8	15	46
10	Srikakulam	47	0.01	2.25	0.01	4.29	20	43	2	4	0	0	23	49	1	2	1	2	22	25
11	Visakhapatnam	64	0.01	1.26	0.02	12.34	24	48	0	0	0	0	30	47	6	9	4	6	24	40
12	Vizianagaram	48	0.11	3.69	0	3.57	19	40	5	10	0	0	22	46	2	4	0	0	24	24
13	West Godavari	53	0	2.89	0.03	10.06	12	23	5	9	0	0	33	62	2	4	1	2	17	36
Total State		744	0	13.15	0	22.96	262		63		26		301		59		32		351	392

ANNEXURE XIX - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2018 FROM DECADAL MEAN OF JAN(2008-17)

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	53	16	30%	-6.63	-0.07	-2.60	8	50%	5	31%	3	19%	37	70%	0.01	6.78	1.60	27	73%	9	24%	1	3%
2	CHITTOOR	46	17	37%	-5.88	-0.02	-1.58	13	76%	1	6%	3	18%	29	63%	0.06	8.11	2.64	14	48%	10	34%	5	17%
3	KADAPA	39	7	18%	-3.12	-0.30	-1.71	3	43%	4	57%	0	0%	32	82%	0.02	53.79	3.81	20	63%	7	22%	5	16%
4	EAST GODAVARI	94	55	59%	-5.37	-0.30	-1.12	44	80%	9	16%	2	4%	39	41%	0.02	9.45	1.08	35	90%	2	5%	2	5%
5	GUNTUR	95	64	67%	-15.92	-0.02	-1.30	53	83%	8	13%	3	5%	31	33%	0.02	5.32	0.68	30	97%	0	0%	1	3%
6	KRISHNA	71	56	79%	-11.89	-0.02	-1.45	44	79%	8	14%	4	7%	15	21%	0.01	0.71	0.28	15	100%	0	0%	0	0%
7	KURNOOL	54	14	26%	-11.35	-0.04	-3.03	9	64%	1	7%	4	29%	40	74%	0.02	16.93	1.77	30	75%	8	20%	2	5%
8	NELLORE	58	33	57%	-8.13	-0.14	-1.70	25	76%	4	12%	4	12%	25	43%	0.01	2.57	1.00	23	92%	2	8%	0	0%
9	PRAKASAM	60	51	85%	-34.90	-0.13	-4.00	28	55%	11	22%	12	24%	9	15%	0.02	2.65	0.59	8	89%	1	11%	0	0%
10	SRIKAKULAM	48	14	29%	-1.35	-0.03	-0.40	14	100%	0	0%	0	0%	34	71%	0.02	4.59	1.16	27	79%	7	21%	0	0%
11	VISAKHAPATNAM	60	35	58%	-14.32	-0.01	-1.82	24	69%	8	23%	3	9%	25	42%	0.01	1.58	0.48	25	100%	0	0%	0	0%
12	VIZIANAGARAM	49	28	57%	-2.91	-0.02	-1.02	25	89%	3	11%	0	0%	21	43%	0.06	1.80	0.60	21	100%	0	0%	0	0%
13	WEST GODAVARI	61	40	66%	-10.56	-0.03	-1.35	33	83%	5	13%	2	5%	21	34%	0.03	2.26	0.53	19	90%	2	10%	0	0%
	STATE FIGIURES	788	**430**	**55%**	**-34.90**	**-0.02**	**-1.34**	**323**	**75%**	**67**	**16%**	**40**	**9%**	**358**	**45%**	**0.01**	**53.79**	**1.30**	**294**	82%	**48**	**13%**	**16**	**4%**

Annexure XX District -wise summarised chemical composition of ground water from GWMS during Pre-monsoon season-2017 (May), Andhra Pradesh

DISTRICT	STATISTIC	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	NO3	SO4	F	TDS	Total alkalinity
ANANTAPUR	Maximum:	7.78	5387	1100	312	151	474	860	0	946	780	698	451	3.20	3738	775
	Minimum:	7.25	491	155	38	11	44	2	0	256	25	3	0	0.28	304	210
	Average:	7.52	2348	537	124	55	230	119	0	600	307	150	130	1.02	1483	492
CHITTOR	Maximum:	7.86	9392	1800	352	224	699	280	0	726	1985	229	201	1.25	3700	595
	Minimum:	7.18	125	40	10	4	11	1	0	43	14	0	2	0.16	74	35
	Average:	7.57	1914	494	117	49	157	24	0	450	271	33	59	0.59	992	369
CUDAPAH	Maximum:	8.15	8300	1400	280	171	1599	80	0	921	2198	397	547	2.26	4928	755
	Minimum:	6.60	312	115	16	13	15	1	0	104	25	0	10	0.28	189	85
	Average:	7.46	2021	399	84	46	285	9	0	459	345	47	119	1.12	1216	376
EAST GODAVARI	Maximum:	8.42	5195	940	124	170	713	130	48	750	1177	83	221	1.36	2824	695
	Minimum:	6.75	452	170	48	1	23	1	0	195	21	0	7	0.25	260	160
	Average:	7.96	1420	402	91	43	135	19	5	434	183	28	63	0.53	830	365
GUNTUR	Maximum:	8.42	10005	3500	500	548	950	400	72	1074	2340	959	1680	3.43	5904	880
	Minimum:	6.55	666	130	6	11	70	1	0	195	78	0	24	0.17	378	160
	Average:	7.58	2492	588	109	77	272	79	1	521	378	122	202	0.87	1557	428
KRISHNA	Maximum:	8.05	11810	2600	260	474	1500	230	0	1251	2765	96	1114	1.48	7083	1025
	Minimum:	7.15	632	90	14	12	23	1	0	232	39	1	2	0.25	386	190
	Average:	7.70	2543	628	90	98	297	45	0	590	443	26	187	0.63	1545	483
KURNOOL	Maximum:	7.86	5858	1540	432	224	850	700	0	1141	737	454	1440	2.30	3698	935
	Minimum:	6.83	340	95	22	4	18	1	0	61	35	1	1	0.20	202	50
	Average:	7.52	2053	485	105	54	227	49	0	413	282	88	212	0.83	1270	339
NELLORE	Maximum:	8.11	4759	700	140	139	798	199	0	744	936	267	432	1.68	2983	610
	Minimum:	6.87	492	110	12	7	50	0	0	31	53	1	14	0.09	290	25
	Average:	7.46	1642	308	63	37	222	40	0	369	260	56	120	0.46	1017	303
PRAKASAM	Maximum:	8.69	8660	2000	440	219	1212	240	30	921	1517	469	2957	2.46	6185	755
	Minimum:	6.86	949	55	4	11	65	1	0	226	82	1	34	0.14	561	185
	Average:	7.69	2572	465	89	59	361	45	1	476	403	85	286	0.78	1619	392

DISTRICT	STATISTIC	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	NO3	SO4	F	TDS	Total alkalinity
SRIKAKULAM	Maximum:	8.35	4212	1020	184	161	450	340	6	598	936	239	288	1.48	2380	490
	Minimum:	7.50	200	55	16	4	12	0	0	18	18	0	4	0.11	119	25
	Average:	7.87	1330	372	93	34	116	32	0	321	208	31	73	0.47	784	264
VISAKHA PATNAM	Maximum:	8.30	3249	600	140	80	495	80	0	641	674	292	633	3.10	1843	525
	Minimum:	6.15	138	45	10	5	5	1	0	24	11	0	1	0.11	84	20
	Average:	7.67	1318	322	71	35	145	17	0	347	180	54	93	0.59	781	285
VIZIANAGARAM	Maximum:	8.88	3285	1100	260	166	239	200	42	628	702	169	131	1.75	1862	515
	Minimum:	6.78	143	50	12	5	6	0	0	43	14	0	1	0.16	72	45
	Average:	7.84	1130	370	88	37	80	21	1	324	150	38	52	0.58	663	267
WEST GODAVARI	Maximum:	8.47	21560	4300	661	644	3094	350	84	1305	7374	171	530	1.08	12323	1070
	Minimum:	7.10	292	110	18	12	12	1	0	43	21	0	1	0.13	161	35
	Average:	8.04	2210	530	114	60	254	40	9	448	441	23	101	0.40	1312	382
STATE FIGURES	**Maximum:**	**8.88**	**21560**	**4300**	**661**	**644**	**3094**	**860**	**84**	**1305**	**7374**	**959**	**2957**	**3.43**	**12323**	**1070**
	Minimum:	**6.15**	**125**	**40**	**4**	**1**	**5**	**0**	**0**	**18**	**11**	**0**	**0**	**0.09**	**72**	**20**
	Average:	**7.68**	**1973**	**465**	**97**	**54**	**220**	**44**	**1**	**450**	**306**	**61**	**134**	**0.69**	**1191**	**372**

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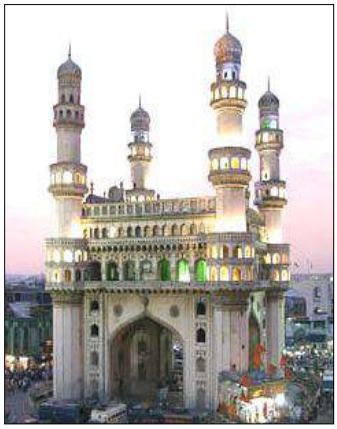

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