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CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

GROUND WATER BROCHURE
WEST GODAVARI DISTRICT, ANDHRA PRADESH
(AAP- 2012-13)

SOUTHERN REGION
HYDERABAD
September 2013

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By

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GROUND WATER BROCHURE
WEST GODAVARI DISTRICT, ANDHRA PRADESH
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WEST GODAVARI DISTRICT AT A GLANCE

Sl No	ITEM	Statistics
1	**GENERAL INFORMATION**	
	i) Geographical area (Sq.km)	7,795
	ii) Administrative Divisions Number of Mandals Number of Revenue Villages Municipalities	 46 910 8
	iii) Population (As on 2011 census)	39,34,782
	iv) Normal Annual Rainfall (mm)	1078
	v) Annual rainfall (2012) (mm)	1612
2	**GEOMORPHOLOGY**	
	Major physiographic units	Alluvial plain, Upland area
	Major drainages	Godavari, Yerrakalava, Tammileru, Ramleru
3	**LAND USE (ha) (2012)**	
	a) Forest area	81,166
	b) Net area sown	4,71,442
4	**MAJOR SOIL TYPES**	Sandy loams, black cotton soils, coastal sands
5	**AREA IRRIGATED UNDER DIFFERENT SOURCES (As on 2010-11)**	
	Dug wells	2663
	Tube wells/Bore wells/Filter point wells	1,71,985
	Tanks/ponds	18,161
	Canals	1,78,762
	Other sources	7,708
	Net irrigated area (ha)	3,79,279
	Gross irrigated area (ha)	5,98,216
6	**GROUND WATER MONITORING WELLS (CGWB) (As on November, 2012)** No.of dug wells No.of piezometers	 20 13
7	**PREDOMINANT GEOLOGICAL FORMATIONS**	Alluvium, Gondwanas, Tertiaries, Deccan Traps & Archaeans
8	**HYDROGEOLOGY**	
	Major water bearing formations Pre-monsoon depth to water level, 2012 Post-monsoon depth to water level, 2012	Rajahmundry & Gondwana Sandstones 0.82 – 12.95 m bgl 0.52 – 14.96 m bgl

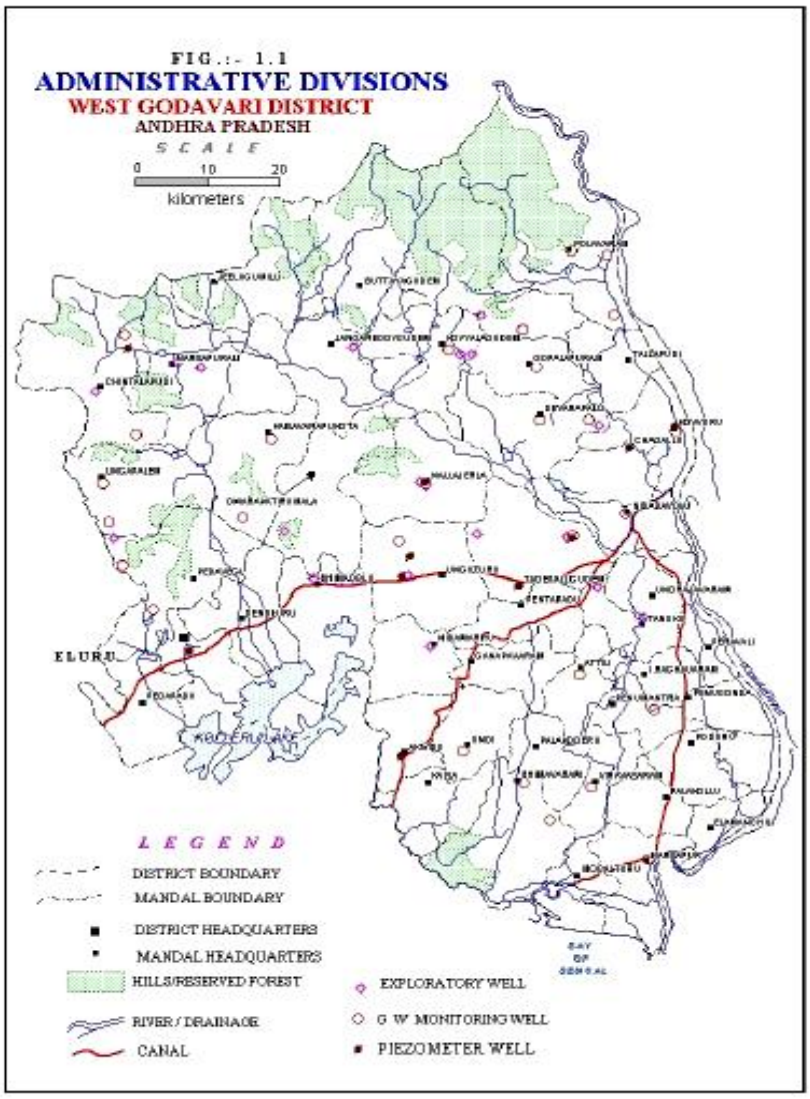
9	**GROUND WATER EXPLORATION BY CGWB (As on 31.03.2012)**	
	No.of wells drilled	32 EW, 11 PZ
	Depth range (m)	45-650.4
	Discharge (litres per second)	10-128
	Storativity (S)	$1.2x10^{-3}$ to $6.8x10^{-4}$
	Transmissivity (sq.m/day)	24-3540
10	**GROUND WATER QUALITY**	
	Presence of chemical constituents more than permissible limit	**EC&Nitrate in Alluvium**
	Type of water	**Ca- Mg, Cl-SO_4; Na- K, Cl-SO_4**
11	**DYNAMIC GROUND WATER RESOURCES (2009)**	
	Annual Replenishable Ground Water availability (ha m)	1,52,617
	Net annual ground water draft (ha m)	49,424
	Projected demand for domestic and industrial uses upto 2025 (ha m)	7409
	Stage of ground water development (%)	36
12	**GROUND WATER CONTROL AND REGULATION**	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	No. of blocks Notified	Nil
14	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	**Water level depletion-uplands** **Water logging-Delta** **Ground water salinity-Delta**

GROUND WATER BROCHURE
WEST GODAVARI DISTRICT, ANDHRA PRADESH

1.0 INTRODUCTION

The West Godavari district with its headquarters at 'Eluru" is one of the nine coastal districts of Andhra Pradesh State. It is located between North Latitudes 16^0 51' and 17^0 30' and East Longitudes 80^0 50' and $81^0$55' covering parts of Survey of India toposheet Nos. 65 C, D, G & H. The total geographical area of the district is 7,795 sq. km constituting 2.84% of the total area of the state. The district population as per 2011 census is 3934782 persons and the density of the population is 508 persons per sq. km. Agriculture is the main stay of population in the district.

1.1 Administrative Divisions: The district consists of 46 revenue mandals **(Fig.1)** grouped under 3 revenue divisions. It has a total of 901 revenue villages and 8 municipalities.



1.2 Drainage: The district is mainly drained by Godavari,Yerrakalava, Tammileru and Ramileru rivers. The river Godavari enters the district near the northeastern corner and after flowing a distance of 72 km, the river bifurcates into Gautami and Vasishta rivers at Vijeshwaram.The Gautami river which marks the district boundary, debouches into Bay of Bengal at Antervedi, draining about 20% of the district area. The other prominent rivers/streams in the district are Yerrakalava, Tammileru, Ramileru, and Guvvaleru. Yerrakalava joins Godavari river while Tammileru and Guvaleru join Kolleru lake.

The Kolleru Lake, the biggest fresh water lake in the country, is situated in the southwestern part of the district. The drainage is mainly dendritic in the northern part of the district and appears to be controlled by structure. Drainage density is more in the northern part and is sparse in southern part. The delta area is served by Godavari canal system and numerous other drains.

1.3 Land Use Pattern: In the district, 81,166 ha. (10.41%) is occupied by forest; 41127 ha. (5.27%) forms barren and uncultivable land; 112237 ha. (14.38%) forms non-agricultural land; 13065 ha. (1.67%) forms permanent pastures and grazing land; 7872 ha. (1.4%) is covered by miscellaneous tree crops and grooves; and 15817 ha. (2.02 %) is fallow land. The net area sown in the district is 480122 ha. (61.55%), while the area sown more than once is 288241 (36.95 %).

1.4 Irrigation & Cropping Pattern: The district is having both surface and ground water resource potential. The delta area is mainly served by surface irrigation, whereas in the upland areas of the district the irrigation is chiefly by ground water. The surface irrigation is through major, medium and minor irrigation projects. Godavari western delta system has an ayacut area of 214560 ha and under medium irrigation, Tammileru Reservoir Project, Vijayarai Anicut, Jalleru Reservoir Project and Yerrakalava Reservoir Project have registered aycuts of 3712, 4340, 1700 and 13709 ha respectively.

The net area irrigated through canals is 178762 hectares. A net area of 174648 hectares is irrigated through ground water. The area irrigated through tanks is only 18161 hectares. The principal crop grown in the district is paddy. The other important crops grown in the district are sugarcane, cashewnut, mango, coconut and tobacco.

1.5 Studies by CGWB: Central Ground Water Board (CGWB) carried out various studies viz., systematic hydrogeological surveys, reappraisal hydrogeological surveys, ground water exploration, geo-physical studies, Ground water modelling and short term investigations. Ground water exploration was initiated by the erstwhile ExploratoryTubewells Organization (ETO) in the year 1958 and in all 32 wells were constructed in different phases. Under Hydrology Project 11 piezometer wells tapping individual aquifers were constructed. Under ground water regime, 33 Ground Water Monitoring Stations (GWMS) are being monitored in the district. Ground water modelling studies were conducted during the year 1978-79 for Yerra Kalava basin by CGWB in collaboration with Cenre for Exploration Geophysics (CGC) of Osmania University.

2. RAINFALL & CLIMATE

The district enjoys tropical humid type of climate with oppressive summer season and good seasonal rainfall. The summer season extends from March to May followed by southwest monsoon season, which lasts till September. October and November constitute the post monsoon or retreating monsoon season. December to February months experience cold weather conditions.

2.1 Rainfall: The normal annual rainfall recorded at Nidadavolu IMD observatory is 1078 mm, of which 738 mm is through south west monsoon from June to September and 246 mm through northeast monsoon from October to December constituting about 68% and 23% of total annual rainfall. District average deficit rainfall years are 2001 (-21 %), 2002 (-44%), 2004 (-23 %), 2009 (-30%) against normal rainfall of 1075.4 mm whereas the highest district average rainfall years are 2010, which is 1900.7 (77% excess). The annual rainfall during 2012 is 1612mm.

The historical data of the I.M.D. station at Nidadavolu for the period (1970-2011) showed that moderate drought conditions prevailed during the years 1982, 1984, 1986, 1992,199, 1997, 2002,2004,2009 &2011 (total 10 years out of 42 years). During the period normal rainfall was received in 22 years and 8 years received excess rainfall and deficit rainfall in 12 years. The statistical parameters computed for Nidadavolu station are:

Mean: 1038 mm. Standard deviation: 275
Co-efficient variation: 24 Maximum: 1698 Minimum.: 463
Long term annual normal rainfall: 1078 m.m.

The monthly normals of hydrometerological parameters are given in Table.1

TABLE 1: MONTHLY NORMALS OF HYDROMETEOROLOGICAL PARAMETERS , NIDADAVOLU

MONTH	RAINFALL (mm)	RAINY DAYS	TEMPERATURE(°C)		RELATIVE HUMIDITY(%)		WIND SPEED (km/hr)	POTENTIAL EVAPOTRANSPIRATION (mm)
			Minimum	Maximum	830hrs	1730hrs		
JAN	3	0.3	18	30.1	79	55	6.5	106
FEB	11	0.5	19.4	32.2	76	49	5.7	116
MAR	6	0.4	22.2	34.1	77	52	5.4	150
APR	17	0.6	25	35.8	77	56	5.9	151
MAY	57	1.9	26.9	38.2	73	50	7.8	162
JUN	132	6.3	26.7	36.7	75	56	12.2	150
JUL	238	12.4	25.1	31.5	85	74	12.7	114
AUG	211	11	25	31.1	86	77	11	110
SEP	157	9.3	24.9	31.6	86	78	8	106
OCT	179	9	23.6	31.3	85	76	5.9	100
NOV	57	4.7	20.7	30.4	79	67	7.1	102
DEC	10	0.7	18.3	29.5	77	58	7	99
MEAN	**1078**	**57.1**	**23.0**	**32.7**	**66.0**	**62.3**	**7.9**	**1466.0**

Source: IMD

2.2 **Other hydrometeorological parameters: T**he mean daily maximum temperature reaches 30^0C and mean minimum daily temperature is 18^0C. The air is humid throughout the year, being more so in coastal region. February to early June is the driest part of the year and relative humidity ranges from 50 to 55% in the afternoon. The monthly mean relative humidity is 80% in forenoon and 62% in the afternoon. Mean monthly wind speed ranges from 5.4 km/hr. in March to 12.7 K.m./hr. in July. The annual potential evapotranspiration is 1467 m.m. The monthly potential evapotranspiration (PET) ranges from 99 m. m. in December to 162.3 m. m. in May.

3.0 GEOMORPHOLOGY & SOIL TYPES

3.1Geomorphology: Physiographically the district is divided into 2 natural regions. viz., Alluvial plain and upland areas. The alluvial plain covers 30 % of the area in southern part of the Eluru – Kovuru railway line while uplands which include agency area constitutes 70% of the total district area. The important landforms in the district include Structural hills, Pediplain, Pediment inselberg complex, Coastal landforms and Valley fills.

3.2 Soil Types: The different type of soils encountered in the district are red soils, black cotton soils, deltaic alluvial soils and coastal sands The red soils are seen mostly around Chintalapudi, Koyyalagudem, Nallajerla and southeast Polavaram villages They are permeable and well drained to moderately well drained. The black cotton soils are encountered in around Eluru, Nidamarru places in the district. Deltaic alluvial soils are very deep and highly fertile.These are seen mostly in around Polavaram, Kovvuru, Nidadavolu and Tanuku places.The coastal sands are seen occurring as patches in the south west and southern most parts of the district.

4.0 GROUND WATER SCENARIO

4.1 Hydrogeology

4.1.1 Geology: The district is underlain by Archaean crystallines, Gondwanas, Deccan Traps, Tertiaries and alluvial sediments. About 45% of the district is underlain by Gondwana formations, 40% is underlain by Alluvium and the rest is by Archaean crystalline rocks. The geological succession is given in Table-2.

Table-2 Geolological Succession

Age	System	Formation	Lithology
Recent to Sub-Recent		Alluvium	Gravel, Sand, silt and clay, Laterite
Unconformity			
Mio-Pliocene		Rajahmundry	Conglomerate ferruginous, gritty, variegated, sandstone and clays
Upper Cretaceous to Lower Eocene		Deccan Traps	Basalt, inter trappean beds and intra trappean marl and shales
Lower cretaceous to Lower Triassic	Upper Gondwana system	Tirupathi Raghavapuram Gollapalii	Gritty and ferruginous sandstone and clays Sandstone, shale and Conglomerate Sandstone and shales
	Lower Gondwana	Chintalapudi	Sandstone shale and clays
Unconformity			
Archaean			Khondalites, Charnockites Granites and Gneisses

4.1.2 Aquifer Systems: The deep exploration has revealed the occurrence of aerially extensive multiple aquifer system. Chintalapudi, Gollapalli and Tirupati sandstones of Gondwana Super Group and Rajahmundry sandstones of Tertiary age form important aquifers. The Tertiary Rajahmundry formation has a minimum of 9 m thickness at Decherla and a maximum of 442 m at Tanuku while the Gondwana has a maximum thickness of 600 m at Achuthapuram. The thickness of coarse granular zones tapped in wells ranges from 24 to 107 m in Chintalapudis, 12-71 in Gollapallis, 20-224 in Tirupatis, and 42-355 m in Rjahmundry outcropped areas. The principle aquifer zones available vary from one to six. The percentage of granular zone thickness ranges from 14 to 93 down to 300 m while the same varies from 25 to 77 beyond 300-600 m depth. The depth of encounterance of Gondwana ranges from 46 to 383 m bgl. The yield of wells ranges from 3,700 to 60,000 lpm for drawdowns of 19 to 25m. The average permeability is of the order of 10 m/day. The transmissivity of aquifers ranges from 25 to 3540 sq.m/day. The storage coefficient is between $8.5x10^{-5}$ and $1.3x10^{-2.}$ The hydrogeological map of the district is shown in **Fig.2**

An attempt was made to bring out the disposition of aquifer zones of the district by preparing a panel diagram **(Fig.3)** and sub surface cross section **(Fig 4).** The northern part of the area is mainly covered by Chintalapudi sandstones and the boreholes are not drilled beyond Chintalapudi sandstones. In the central part of the district more than one geological formation is encountered while in the southern part, the boreholes could not be drilled beyond alluvium because of its huge thickness. The granites are encountered at shallow depths near Gopalapuram in northeastern part of the area and at Jeelakarragudem and Pragadavaram in western part of the district. From the panel diagram five faults could be inferred between (1) Achutapuram and Gopalapuram (2) Bhimadolu and Kaikaram (3) Gopalapuram and Chityala (4) Dharmajigudem and Kallacheruvu and (5) T Nyampalle and Denduluru.

FIG :- 2

HYDROGEOLOGY

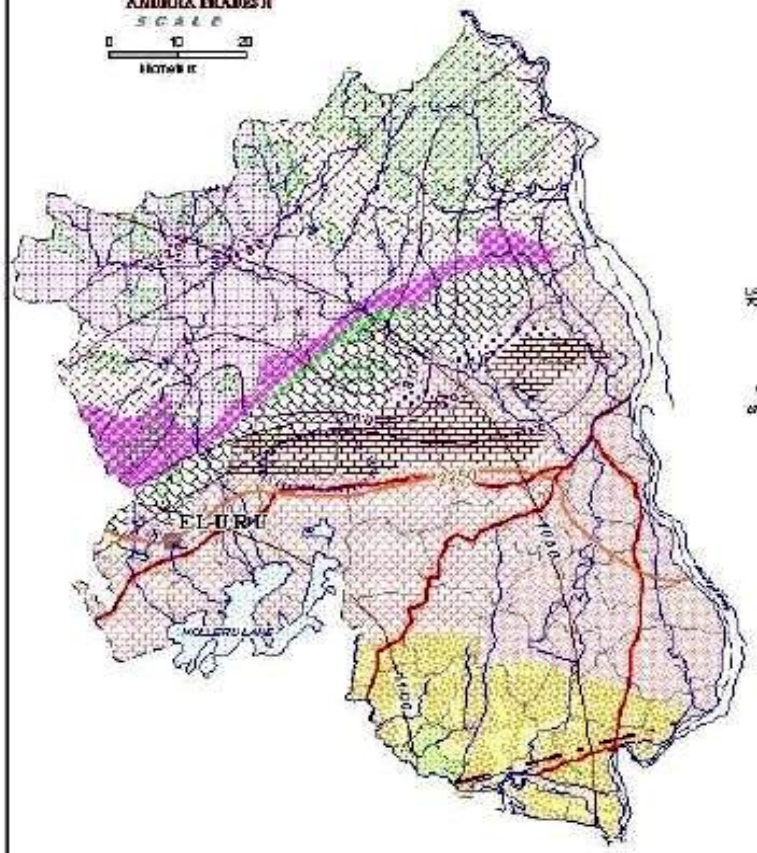
WEST GODAVARI DISTRICT

ANDHRA PRADESH

SCALE

0 10 20

Kilometres



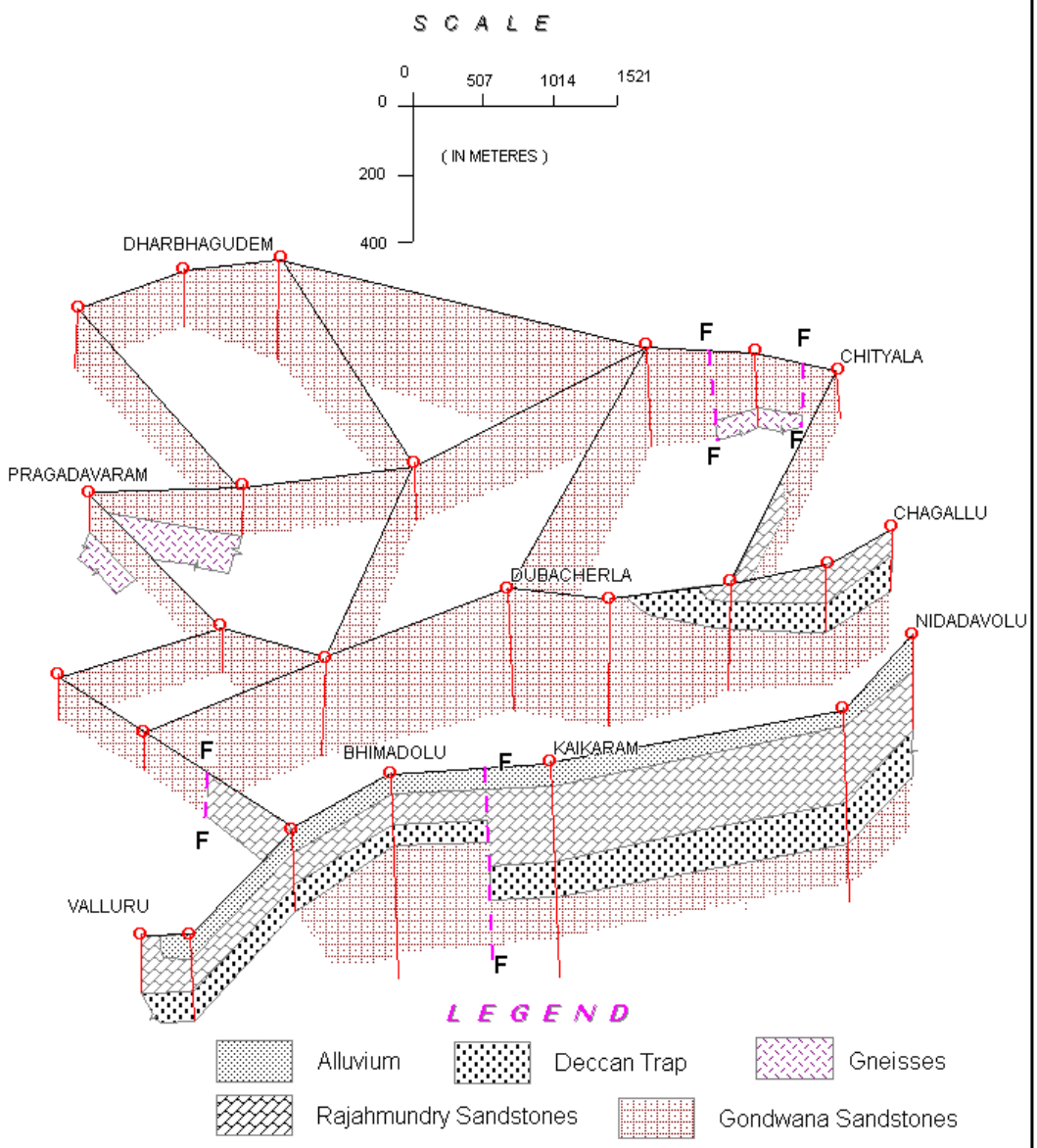
LEGEND

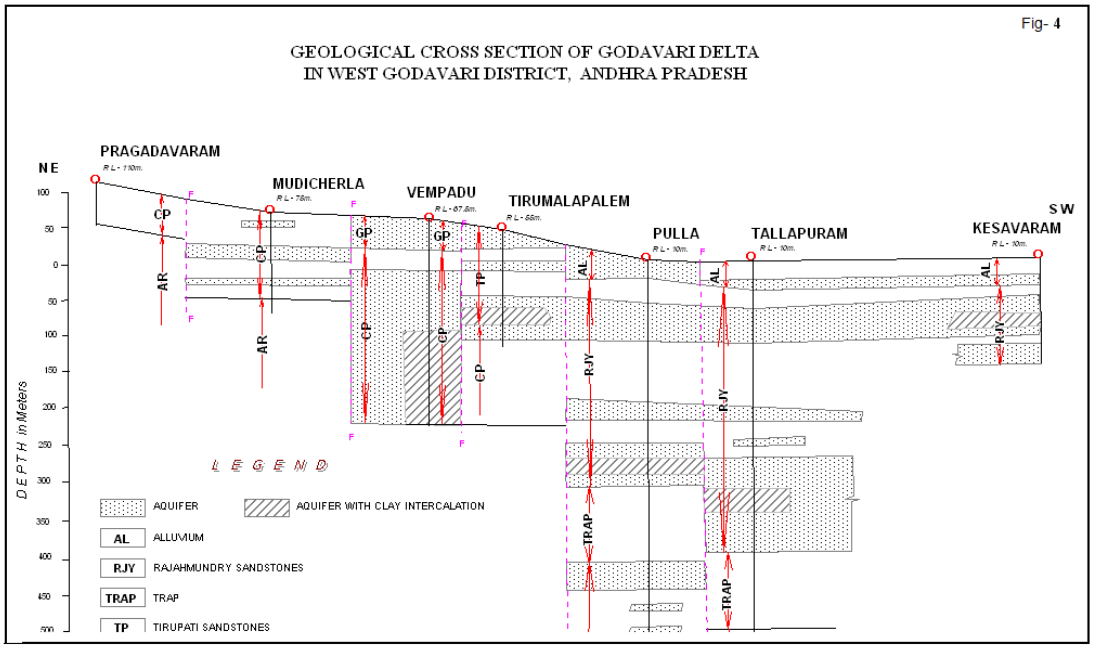
AGE	GROUP	LITHOLOGY	GROUND WATER PROSPECTS
HOLOCENE		ALLUVIUM: SILT AND CLAY (MUD FLAT)	FLAT, LOW LYING MARSHY AREA, GROUNDWATER SALINE
		ALLUVIUM: SAND, SILT AND CLAY (COASTAL PLAIN)	GENTLE PLAIN, MARINE SEDIMENTS, SALINE WATER BUT FOR FRESH WATER LENSES
		ALLUVIUM: GRAVEL, SAND, SILT AND CLAY (DELTAIC PLAIN)	FLAT TO GENTLE SLOPE, SHALLOW AQUIFERS FRESH, DEEPER AQUIFERS SALINE. 1-10 lps
		RIVER ALLUVIUM: SAND, SILT AND CLAY, FLOOD PLAIN	NEARLY LEVEL PLAIN, SHALLOW AQUIFERS FRESH, DEEPER AQUIFERS SALINE. 1-10 lps
MIOPLIOCENE	DECCAN TRAPS	RAJAHMUNDRY FORMATION: SANDSTONES, CLAYS, SHALES AND CONGLOMERATES	EXTENSIVE PROLIFIC AQUIFERS, UNCONFINED, SEMI CONFINED CONDITIONS. SUITABLE FOR MEDIUM DEEP TUBEWELLS. 15-35 lps
LATE CRETACEOUS TO EARLY EOCENE		BASALTS	MASSIVE, OCCASSIONALLY FRACTURED, UNCONFINED TO SEMI CONFINED CONDITIONS. LIMITED GROUND WATER DEVELOPMENT PROSPECTS
LOWER CRETACEOUS TO UPPER GARDWANAS	TIRUPATI SANDSTONE	TRIPATI FORMATION: SANDSTONES, CLAYS, SHALES AND CONGLOMERATES	PROLIFIC MULTILAYERED AQUIFER SYSTEMS, UNCONFINED, SEMI CONFINED AND CONFINED CONDITIONS, FREE FLOW CONDITIONS WHEN OVERLAIN BY TRAPS. SUITABLE FOR DEEP TUBEWELLS. 10-30 lps. TUBEWELLS. 16-35 lps.
		RAJAHMUNDRY FORMATION: SHALES	POOR AQUIFERS. LIMITED GROUND WATER DEVELOPMENT PROSPECTS.
		PALAKAPALLY FORMATION: SANDSTONES, SHALES, CLAYS	EXTENSIVE MULTILAYERED AQUIFERS. UNCONFINED, SEMI CONFINED AND CONFINED CONDITIONS. SUITABLE FOR TUBEWELLS 6-15 lps.
	GUNDLAKAMMA FORMATION	GUNDLAKAMMA FORMATION: SANDSTONES, SHALES, CLAYS AND CONGLOMERATES	EXTENSIVE MULTILAYERED AQUIFERS. UNCONFINED, SEMI CONFINED AND CONFINED CONDITIONS. FREE FLOW CONDITIONS EXIST. SUITABLE FOR DEEP TUBEWELLS 15-20 lps.
MIDDLE PROTEROZOIC TO ARCHAEAN	EASTERN GHATS	GRANITES, GNEISSES, HYPERSTHENITES AND CHARNOCKITES	WEATHERED AND FRACTURED ZONES SUITABLE FOR GROUNDWATER DEVELOPMENT. UNCONFINED TO SEMI CONFINED CONDITIONS. SUITABLE FOR LARGE DIAMETER WELLS AND BOREWELLS 1-5 lps.

- 1-0-0 WATER TABLE CONTOUR (in mts)
- 2250 AREA WITH ELECTRICAL CONDUCTIVITY > 2250 micromhos/cm at 25° C
- FREE FLOW ZONE (ONCE EXISTING)
- BEACH RIDGE
- EXPLORATORY BOREWELL
- LINEAMENT
- STRAND LINE
- HILLS/FOREST

Fig- 3

PANEL DIAGRAM SHOWING DISPOSITION OF GEOLOGICAL FORMATIONS IN WEST GODAVARI DISTRICT, ANDHRA PRADESH





Raghavapuram shales are exposed at the surface between Dubacherla and Achyuthapuram.

Fig.4 presents the section A-A' running in the NE-SW direction covering the boreholes at Pragadavaram, Mudicherla, Vempadu and Kesavaram. The section has brought out four faults between (1) Mudicherla and Vempadu (2) Vempadu and Tirumalapalem (3) Tirumalampalem and Pulla and (4) Pulla and Tallapuram. The occurrence of Trap formation at different depths between Tallapuram and Pulla confirms the presence the fault.

The formations at Pragadavarm and Mudicherla are mostly cleayey in nature. However, two aquifers are identified at Mudicherla, which are relatively les thick as compared to other boreholes. Two aquifers are delineated at Vempadu – the top one lies in Gollapalli formation and the bottom likes in Chintalapudi formation. Similarly at Tirumalampalem, three aquifers viz. two in Tirupati and one in Chintalapudi formation are identified. **At Pulla, six aquifers are deciphered viz. one aquifer in the alluvium, three aquifers in Rajahmundries and two aquifers deciphered viz. one aquifer in the alluvium, three aquifers in Rahahmundries and two aquifers in Tirupatis.** The boreholes drilled at Kesavaram indicated three aquifers i.e., one in alluvium and the other two in Rjahmundries.

The exploratory drilling has brought out the presence of Traps at different depths with varying thickness. The Deccan Trap acts as a confining layer to the underlying Gondwana aquifers and presents a conspicuous marker horizon. The top of Deccan trap occurs at 1.3 m bgl at Prakasaraopalem. It occurs at a depth of 460 m at Rachuru, where drilling was stopped. **The number of flows varies from one to six. The top most flow is seen at Eluru. The total thickness of trap is of the order of 3.5 m to 82 m.**

4.1.3 Occurrence & Yield Pattern: Ground water occurs under unconfined, semi to confined conditions in different formations of the area. In the crystalline formation the yield of the open wells range from 20 – 50 m^3/day and the discharge of bore wells vary

from 17.28 to 648 m^3/day. The Chintalapudi formations are relatively hard on surface and forms good aquifers with granular zone thickness varying from 24 – 107m and the yield of wells ranges between 604.8 and 2419.2 m^3/day and the transmissivity values are in the order of 50 to 1338 m^2/day. In Gollapalli sandstone, the thickness of granular zones varies from 12.0 and 71.0 m and the depth of the wells range between 75 and 120m with discharges of 691.2 to 1382.4 m^3/day. Raghavapuram shales have a maximum thickness of 10m and are poor aquifers. In Tirupati sandstone formation, the depth of the wells range between 99 and 250m with yields varying from 345.6 to 1555.2 m^3/day and the thickness of granular zone is in the order of 20 – 93m. The depth of the wells in Rajahmundry sandstones range between 32 and 611m and the discharge varied from 1296 to 3024 m^3/day with thickness of granular zone in the order of 18 to 175m (Table-3). Ground Water development is limited in alluvium and in general the deeper zones are brackish to saline in nature.

Table-3: Formation-wise Yield Pattern

Sl No	Formation	General depth range of wells (m)	Thickness (m)	Discharge range (lps)	Trans-missivity (m^2/day)
1	Chintalapudi formation	60-120	24-107	7-28	50-1465
2	Gollapalli formation	75-120	12-71	8-16	247-1055
3	Tirupati formation	99-250	20-224	4-18 (occasionally upto 45)	76-846
4	Rajahmundry Formation	32-611	18-175	13-35 (occasionally upto 128)	

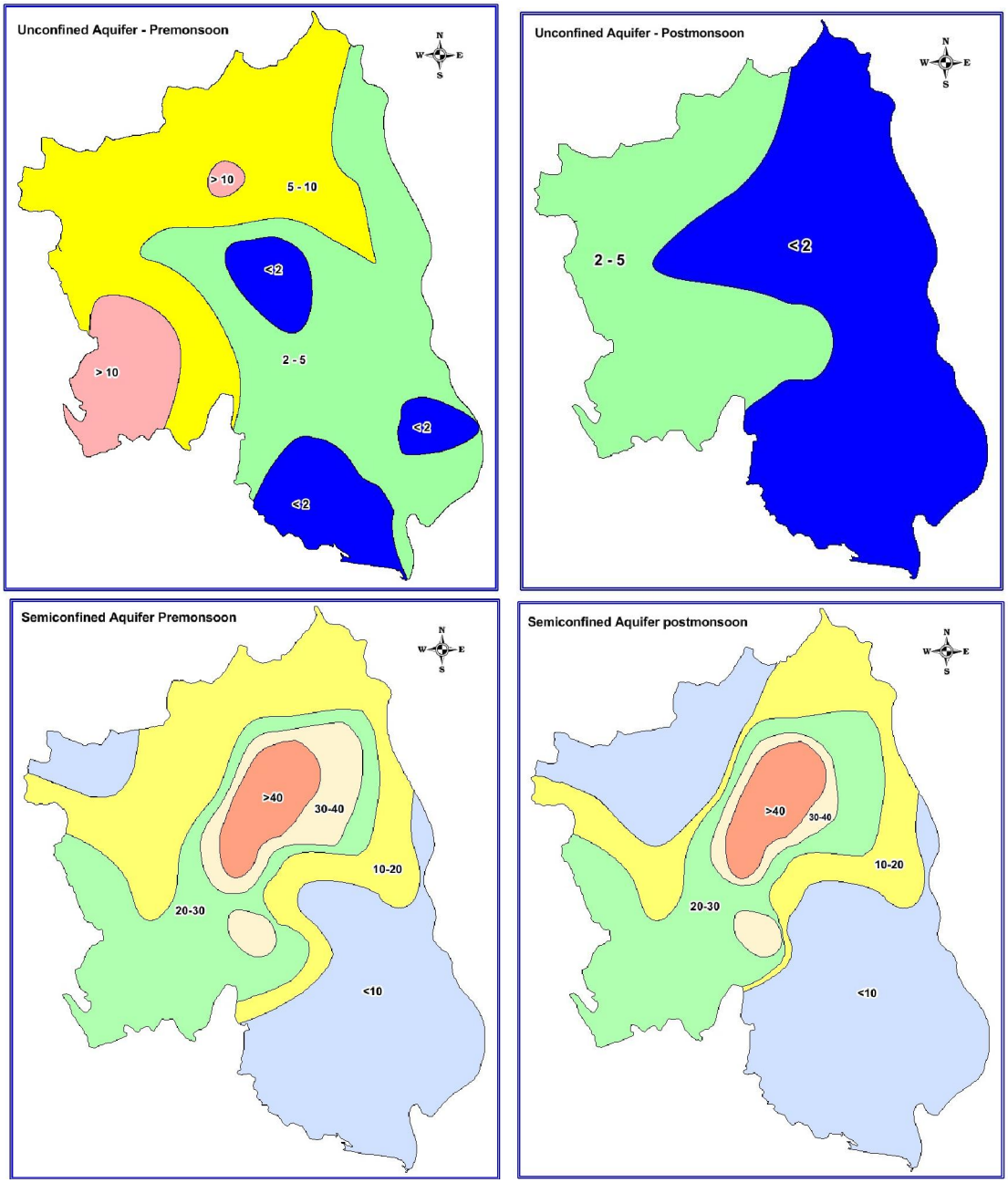
4.1.4 Water Level Behaviour: The pre-monsoon depth to water level (May 2012) ranges from 0.79 to 14.49 m bgl in alluvial formation and 0.82 to 42.64 m bgl in sedimentaries and during post monsoon (Nov-2012) season it varies from 0.43-13.67 m bgl. in alluvium and 0.52 to 44.47 m. in sedimentary formation (Table-4). Fig -5 depicts depth to water level for pre-monsoon and post monsoon seasons (2012) for unconfined and semiconfined aquifers. During the post monsoon season most of the area in alluvium is water logged. The water table gradient is steep in northern part and is very gentle in southern part and the direction of ground water flow is towards southeast. The total decline in the piezometric levels during the last two decades is high and it varies upto 2.08 m/annum in sedimentaries. During the last two decades there is decline in the rate of growth of dug wells and increase in the rate of growth of tube wells in uplands resulting in decline in piezometric heads considerably. Hydrographs of select ground water monitoring wells are shown in Fig.6.

Table-4 Depth to Water Level Ranges in different formations

Aquifer	Formation (Data points)	Pre-monsoon (m bgl)	Post-monsoon (m bgl)	Fluctuation (m)
Unconfined	Alluvium (17)	1.02 to 12.95	<1 to 4.94	0.43 to10.30
	Sandstones (9)	0.82 to 9.18	0.52 to 9.47	-0.30 to 4.37
	Crystallines (10)	4.13 to 8.70	2.61 to 14.96	-1.00 to 1.52
Semi-confined	Alluvium (3)	2.57 to 14.49	2.81 to 13.67	-0.24 to 0.82
	Sandstones (10)	3.70 to 42.64	6.92 to 44.47	-9.68 to 4.33

(17) : No.of wells analysed Source: CGWB & GWD Monitoring well data

Fig-5 Depth to Water Level – Pre-Monsoon (May 2012) Post-Monsoon Seasons (2012)



4.2 Ground Water Resources

As per the 2008-09 ground water resource estimation, the total net ground water availability in the district is of the order of -138590 ha.m and the existing ground water draft for all uses is 49424 ha.m leaving a ground water balance of 84104 ha m ha.m for future irrigation development. The present stage of ground water development in the district is 61% in non-command and 12-% in command area with **overall stage of ground water development of 36%.** All the mandals are falling in safe category, contrary to 10 over exploited, 4 critical mandals during 2004-05. The stage of development is generally high in area occupied by sedimentaries, while it is low in canal command areas,

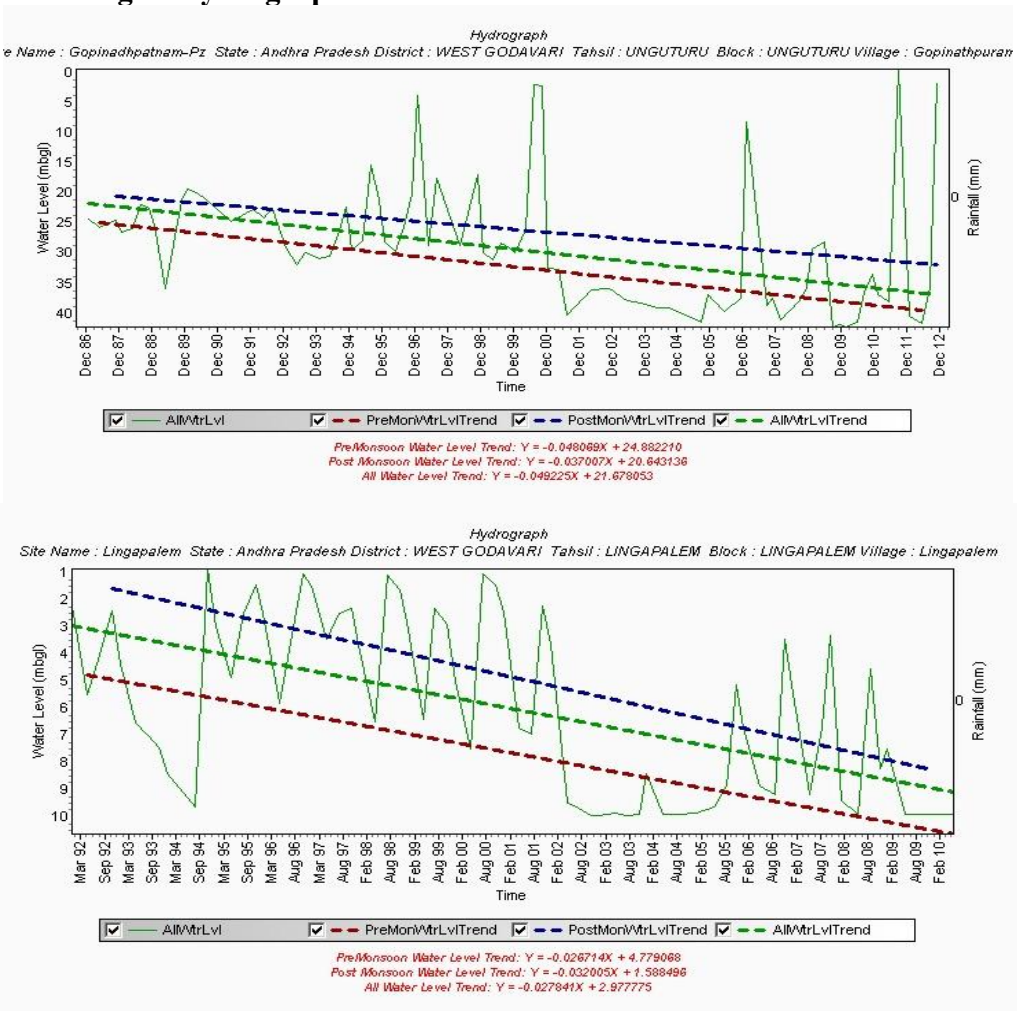
suggesting the need for judicious exploitation of ground water resources in future. Mandal-wise ground water resources are shown in Appendix-I.

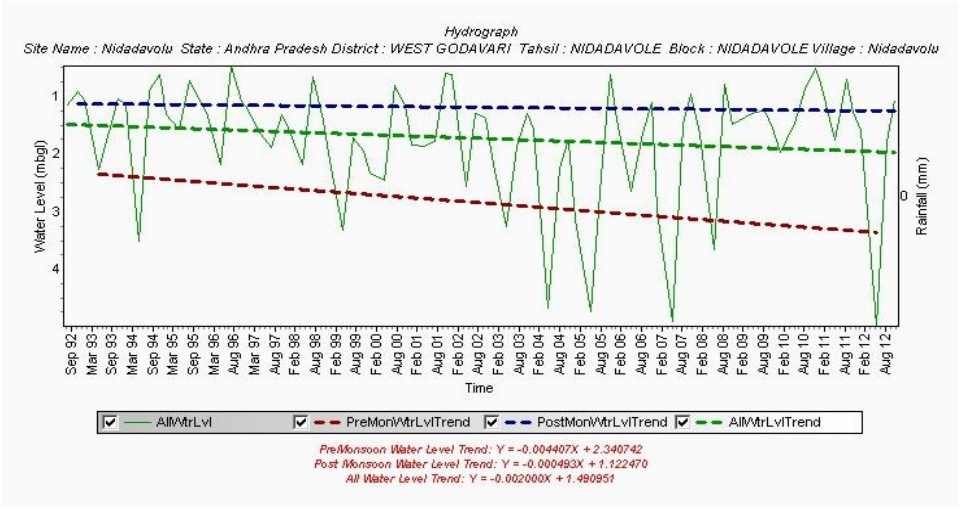
4.3 Hydrochemistry

The chemical quality of ground water in crystallines and sedimentaries is good for domestic and irrigation purposes. However, in alluvium the quality varies widely from good to brackish and saline.

4.3.1 Shallow aquifers: A perusal of chemical analysis of 18 ground water monitoring stations indicates that, in general the chemical quality of shallow phreatic aquifer in crystalline and sedimentary formations, is within the standard limits of drinking water specifications.

Fig-6. Hydrographs of Select Wells in West Godavari District





However, in the places like Jangareddygudem and Polavaram the nitrate is high, due to local pollution. In alluvium in 22% of samples nitrate pollution is observed, and also the water is brackish and contains the concentrations of various constituents in excessive limits.

The suitability of water for irrigation purpose is assessed as per US Salinity Diagram. It is observed that in all, 11% of samples fall in C_2 S_1 category; 67% in C_3 S_1 category; 4% in C_2 S_2 category; and 11% in C_4 S_1 category. However, 2 samples fall beyond the range indicating that they are not fit for irrigation. In sedimentary formation the SAR is low and salinity hazard is high in 84% samples. Similarly in alluvium, salinity hazard is very high (C_4S_1) in 27% of samples indicating the unsuitability of water for irrigation under ordinary condtions and water is unfit for irrigation in 18% of samples, while 45% of samples water falls in C_3S_1 category. The water in crystalline formation is suitable for irrigation with 75% of samples falling in C_3S_1 category and rest in C_2S_1 category.

4.3.2 Quality of water from deeper aquifers:

In general, the ground water is suitable for drinking and irrigation purposes in crystallines, sedimentaries while that occurring in alluvium the water is not suitable purpose and irrigation purpose under ordinary conditions.

5.0 GROUND WATER MANAGEMENT STRATEGY

Ground water is the main source of irrigation in crystallines and there is much scope for ground water development. However, the available resources in these rocks is site specific. Hence, in order to avoid wasteful expenditure on drilling and encountering dry wells in hard rok areas, it is necessary to carry out comprehensive surveys before drilling of bore wells. Generally dug wells are suitable in crystalline rocks in valley portions. Bore wells are feasible wherever these rocks are deeply weathered and fractured. Run off is also high in these areas. Therefore, it is suggested to construct rainwater-harvesting structures upstream of irrigated areas to augment ground water resources.

In sedimentary tract, the phreatic aquifers are mostly dry with the over development of ground water, where it is developed by means of tube wells or dug-cum-bore wells. The sedimentaries comprise multi-aquifer systems where the number of

aquifers varies from one to six. The aquifers are made up of fine to coarse-grained sandstones with the thickness of more than 600m, with discharges varying from 4.0 to 45 lps. However, the wells have to be properly constructed following well design norms. It is always necessary that wells are to be spaced as per norms to avoid lowering of piezometric surface and increase in pumping lift. It is known that most of the ground water development has taken place in private sector and wells are constructed in improper way and well assembly is lowered without studying the granular zones and seldom gravel packing is done. Generally casing is provided down to depth range of 35 – 60 m. beyond which slotted casing is provided and the slot size is commonly 2 m. m. and the tube wells are packed with gravel only in selected cases. Based on the available data NABARD has suggested 90 to 150 m. depth for tube wells constructed in sedimentary area with 200 to 150 mm assembly and with 40 to 60 metres of housing and provided with 10 to 15 H.P. There is a need to encourage small and marginal farmers to go for drip irrigation by providing necessary incentives and guidance and to adopt suitable cropping pattern and agricultural practices for proper management of ground water resources.

In alluvium, it is highly necessary that fresh water repositories (paleo channels) are to be protected from over pumping. Possibility of optimum utilization of surface and ground water may be considered locally after micro level surveys considering the quality constraint, to contain water logging. The wells are to be pumped at optimium pumping rate following spacing norms to avoid undesirable effect of saline water intrusion. Environmental protection measures are to be followed in aqua culture practices.

6.0 GROUND WATER RELATED ISSUES & PROBLEMS

The ground water issues in the district include water table depletion, ground water salinity, water logging, corrosion, aqua culture.

Water table depleted areas: Due to increased ground water development over the past three decades in upland areas of the district, there is depletion of water table and piezometric levels. In alluvial area however there are no significant changes. The water table depletion in general is reported to exist in all the upland mandals underlain by sedimentaries. At places in the area the water levels have declined down to as deep as 40 m bgl. The maximum fall was recorded at G.Kothapalli (2.08 m/annum) followed by Koyyalagudem (1.86 m/annum).The depletion of piezometric heads is also reflected by the fact that free flow of wells has virtually stopped in many wells (Bhimadolu-Kaikaram areas) due to excessive ground water draft in the area.

Water logging: During the post monsoon season, most of the canal command area is under water logged condition. However, during the pre-monsoon, part of the area has water levels between 2.0 and 5.0 m bgl. Therefore, it is evident that command area is either water logged or prone to water logging and the area also is seasonally water logged. The excessive irrigation, flat topography, high rainfall poor drainage and soils are the factors that are responsible for the water logging in the district.

Ground Water Salinity: It is observed from ground water exploration studies that the deeper aquifers are brackish. Based on the available data it is observed that an area of 3100 sq. kms. is affected due to salinity and also as per the U.S. salinity Laboratory classification, water is unsuitable for irrigation where an area of 2650 sq. kms. is having E.C. more than 2250 μ/siemens/c.m. There are 15 mandals affected by salinity, of these some mandals like Mogalturu, Narsapur, Kalla, Bhimavaram and Elamanchali are susceptible to tidal influence. There are some mandals like Bhimadole, Denduluru, Eluru and Peddapadu

which are located away from the coast and tidal influence. Considering that the delta is of prograding nature and subjected to transgressions and regressions in the past, it could be summarised that the poor quality water is mainly due to depositional environment of the formation though, water logging, intensive irrigation, tidal influence, aqua culture practices also contribute to some extent.

Special ground water problems:

Corrosion: The problem of corrosion exists in some parts of upland areas of the district underlain by sedimentaries. It is reported to occur in the district into two zones. i) Bhimadole-Pulla area: villages falling in this zone are Bhimadole, Suruppagudem, M.Nagulapalli, Surbhapuram, Buttaigudem, A.Gokavaram, Amberpeta and Nallamadu. Corrosion is also reported to occur to some extent in Jaganathapuram and Madhavaram villages in Tadepalligudem mandal in east central parts of the district where similar hydrogeological environment exist. ii).Dwaraka Tirumala – Koyyalagudem area: Villages falling in this zone are Yadavolu (Devarapalli mandal) Jaganathapuram and Chinnaigudem (Gopalapuram mandal) Kanakadripuram, Kannaigudem, Yerranapeta, Ponguturu and Gavaravaram (Koyyalagudem mandal), Pothavaram (Nallajerla mandal), I.S.Jaganathapuram, Timmapuram and Kommera (Dwaraka Thirumala mandal). Considering this, farmers shifted to PVC pipes to avoid corrosion.

Aquaculture: In coastal areas of the district during the last decade there has been enormous growth of aqua culture farming. In this district about 11,740 units with water spread area of 6,72.278 hectares under prawn culture exists in the 5 coastal mandals viz., Narsapuram, Mogalturu, Bhimavaram, kalla and Akiveedu. Though aquaculture is prevalent in the coastal area of the district, no systematic study has been taken up on the impact of aquaculture on ground water.

7.0 RECOMMENDATIONS

1. **The balance ground water resource needs to be developed with abundant caution following spacing norms, well design, optimum pumping rates and recommended cropping pattern.** During the last three decades there is considerale decline in piezometric levels of confined aquifes. **In this context, it is recommended to keep the distributary canals unlined under the proposed Polavaram Project in sedimentary area which help in building of water levels. Farmers may be advised not to grow sugarcane crop in water stress areas.**

2. Fresh water repositories (paleo channels, sand ridges) in delta are to be protected from over pumping.
3. In the deltaic regions the irrigation is chiefly dependent on canal water supply. The water levels are shallow and water logging problem exists and ground water resources lie untapped. Therefore the prospects of taking up of conjunctive use of both surface and ground water need to be taken up after micro level surveys to understand disposition of aquifer geometry, quality variation in depth and optimum pumping rates so as not to disturb fresh water – salt water interface.

4. Studies on aqua culture need to be taken up to analyse the quality changes as well as impact on ground water and pollution. Piezometers need to be constructed in coastal tract to montor quality on continous basis.
5. Ground water development in tribal pockets of the district is very less and there is further scope for further ground water development to create more irrigation potential. However, the occurrence of ground water is site specific. Wells have to be drilled in favourable places like lineament zones, valley fill and pediplain areas.

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Appendix-I

Mandal Wise Dynamic Groundwater Resources of the West Goadavari District, Andhra Pradesh [2008-2009] [In Ha.m.]

Sl. No.	Mandal	Command/Non-command	Net annual ground water availability	Existing gross ground water draft for all uses	Provision for domestic and industrial requirement supply to 2025	Net ground water availability for future irrigation development	Stage of ground water development	Category(Safe/Semi-critical/Critical/Over-exploited)
1	2	3	4	5	6	7	8	9
		Com	139	74	26	65	53	Safe
		N.C.	5569	3748	226	1638	67	Safe
		P.Q.	0	0	0	0	0	
1	Chintalapudi	Total (Ex.PQ)	5708	3822	252	1703	67	Safe
		Com	963	291	8	667	30	Safe
		N.C.	2692	2302	92	325	86	Safe
		P.Q.	0	0	0	0	0	
2	Lingapalem	Total (Ex.PQ)	3655	2593	100	992	71	Safe
		Com	0	0	0	0	0	
		N.C.	5692	3658	283	1762	64	Safe
		P.Q.	0	0	0	0	0	
3	T. Narasapuram	Total (Ex.PQ)	5692	3658	283	1762	64	Safe
		Com	0	0	0	0	0	Safe
		N.C.	2300	1321	132	873	57	
		P.Q.	0	0	0	0	0	
4	Jeelugumilli	Total (Ex.PQ)	2300	1321	132	873	57	Safe
		Com	0	0	0	0	0	
		N.C.	6705	1593	521	4598	24	Safe
		P.Q.	0	0	0	0	0	
5	Buttayagudem	Total (Ex.PQ)	6705	1593	521	4598	24	Safe
		Com	138	0	0	138	0	Safe
		N.C.	1930	813	194	929	42	Safe
		P.Q.	0	0	0	0	0	
6	Polavaram	Total (Ex.PQ)	2068	813	194	1067	39	Safe
		Com	409	0	0	409	0	Safe
		N.C.	1321	749	141	572	57	Safe
		P.Q.	0	0	0	0	0	
7	Tallapudi	Total (Ex.PQ)	1730	749	141	981	43	Safe
		Com	844	195	27	622	23	Safe
		N.C.	2707	1744	83	963	64	Safe
		P.Q.	0	0	0	0	0	
8	Gopalapuram	Total (Ex.PQ)	3551	1939	110	1585	55	Safe
		Com	0	0	0	0	0	
9	Koyyalagudem	N.C.	2863	2177	96	686	76	Safe

		P.Q.	0	0	0	0	0	
		Total (Ex.PQ)	2863	2177	96	686	76	Safe
		Com	0	0	0	0	0	
		N.C.	4512	2626	52	1886	58	Safe
		P.Q.	0	0	0	0	0	
10	Jangareddigudem	Total (Ex.PQ)	4512	2626	52	1886	58	Safe
		Com	43	18	9	25	42	Safe
		N.C.	2844	1979	108	765	70	Safe
		P.Q.	0	0	0	0	0	
11	Kamavarapukota	Total (Ex.PQ)	2887	1997	117	790	69	Safe
		Com	832	220	30	612	26	Safe
		N.C.	4121	2710	136	1318	66	Safe
		P.Q.	0	0	0	0	0	
12	Dwarakatirumala	Total (Ex.PQ)	4953	2930	166	1930	59	Safe
		Com	709	0	11	698	0	Safe
		N.C.	3118	2167	134	929	69	Safe
		P.Q.	0	0	0	0	0	
13	Nallajerla	Total (Ex.PQ)	3827	2167	145	1627	57	Safe
		Com	208	114	5	89	55	Safe
		N.C.	3455	2341	302	818	68	Safe
		P.Q.	0	0	0	0	0	
14	Devarapalli	Total (Ex.PQ)	3663	2455	307	907	67	Safe
		Com	629	104	42	525	17	Safe
		N.C.	3023	1531	172	1492	51	Safe
		P.Q.	0	0	0	0	0	
15	Kovvuru	Total (Ex.PQ)	3652	1635	214	2017	45	Safe
		Com	133	85	14	48	64	Safe
		N.C.	2716	1588	122	1062	58	Safe
		P.Q.	0	0	0	0	0	
16	Chagallu	Total (Ex.PQ)	2849	1673	136	1110	59	Safe
		Com	1775	75	46	1683	4	Safe
		N.C.	769	354	71	415	46	Safe
		P.Q.	0	0	0	0	0	
17	Nidadavole	Total (Ex.PQ)	2544	429	117	2098	17	Safe
		Com	1606	634	35	945	39	Safe
		N.C.	2451	661	168	1754	27	Safe
		P.Q.	0	0	0	0	0	
18	Tadepalligudem	Total (Ex.PQ)	4057	1295	203	2699	32	Safe
		Com	2332	37	41	2258	2	Safe
		N.C.	2100	1368	83	678	65	Safe
		P.Q.	0	0	0	0	0	
19	Unguturu	Total (Ex.PQ)	4432	1405	124	2936	32	Safe
		Com	2226	36	41	2162	2	Safe
20	Bhimadole	N.C.	1603	1367	96	147	85	Safe

		P.Q.	0	0	0	0	0	
		Total (Ex.PQ)	3829	1403	137	2309	37	Safe
		Com	542	99	35	443	18	Safe
		N.C.	3497	2792	138	581	80	Safe
		P.Q.	0	0	0	0	0	
21	Pedavegi	Total (Ex.PQ)	4039	2891	173	1024	72	Safe
		Com	2869	71	81	2718	2	Safe
		N.C.	572	464	31	81	81	Safe
		P.Q.	0	0	0	0	0	
22	Pedapadu	Total (Ex.PQ)	3441	535	112	2799	16	Safe
		Com	3033	149	68	2816	5	Safe
		N.C.	0	0	0	0	0	
		P.Q.	0	0	0	0	0	
23	Eluru	Total (Ex.PQ)	3033	149	68	2816	5	Safe
		Com	1427	541	94	838	38	Safe
		N.C.	1244	1121	74	88	90	Safe
		P.Q.	0	0	0	0	0	
24	Denduluru	Total (Ex.PQ)	2671	1662	168	926	62	Safe
25	Nidamarru	Com /PQ.	6288	0	0	6288	0	Poor quality
26	Ganapavaram	Com /PQ.	7490	0	0	7490	0	Poor quality
27	Pentapadu	Com /PQ.	10524	158	79	10366	2	Poor quality
28	Tanuku	Com.	6074	354	538	5359	6	Safe
29	Undrajavaram	Com.	6846	1450	725	5396	21	Safe
30	Peravali	Com.	5281	912	327	4042	17	Safe
31	Iragavaram	Com.	4892	549	313	4030	11	Safe
32	Attili	Com.	6518	60	322	6136	1	Safe
33	Undi	Com /PQ.	12036	0	0	12036	0	Poor quality
34	Akiveedu	Com /PQ.	14824	0	0	14824	0	Poor quality
35	Kalla	Com /PQ.	8131	0	0	8131	0	Poor quality
36	Bhimavaram	Com /PQ.	8801	0	0	8801	0	Poor quality
37	Palakoderu	Com /PQ.	6971	0	0	6971	0	Poor quality
38	Veeravasaram	Com /PQ.	21139	0	0	21139	0	Poor quality
39	Penumantra	Com.	7084	480	293	6311	7	Safe

40	Penugonda	Com.	6712	524	524	5664	8	Safe
41	Achanta	Com.	6522	1178	299	5045	18	Safe
42	Poduru	Com /PQ.	8103	428	214	7675	5	Poor quality
43	Palakollu	Com /PQ.	7212	480	16	6732	7	Poor quality
44	Yelamanchili	Com /PQ.	8131	752	0	7379	9	Poor quality
45	Narasapuram	Com /PQ.	9902	0	0	9902	0	Poor quality
46	Mogalturu	Com /PQ.	4694	0	0	4694	0	Poor quality
		Com.	70786	8250	3954	59744	12	Safe
		N.C.	67804	41174	3455	24360	61	Safe
		P.Q.	134246	1818	309	132428	1	
District Total		Total (Ex.P.Q)	138590	49424	7409	84104	36	Safe

Com-Command; N.C-Non-Command; PQ – Poor Quality