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FAILURE OF OPEN WELLS IN HUKKERI TALUK(KARNATAKA)

HARD ROCK REGIONAL CENTRE
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PREFACE

In the present atmosphere of increasing demand of ground water, failure of open wells, specially in Hard Rock region are very often noticed due to disbalance between the yield and exploitation of ground water resources. Concept of safe yield has been over shadowed due to less meteoric inputs and human's influence of over exploitation. Therefore necessity of studying the failure of Open Wells can not be ignored any further.

Pumping and Recovery test is a method of estimating the yield of a well. Number of methods are available but selection of a best suited method is a big problem, specially for Hard Rock regions where the media of flow is anisotropic and mostly ground water flow is through joints and fractures. Parameters like Transmissivity and Storativity may not project the clear picture as it would be with well rock Permeability.

Very often the theory of safe yield remains confined to mere technical publications only because hardly there exist any scope of increasing meteorological inputs in a location on one side and on the other hand forcing regulations are not available to limit the groundwater draft. In such a situation only alternative remains to be seen is, the scope of artificial recharge.

Present study has been carried out in the Hukkeri Taluk of Belgaum district of Karnataka state by Mr. P. K. Majumdar, Scientist'C', Dr. B. K. Purandara, SRA, and Mr. P. R. Rao,JRA as a part of the work program of Regional Centre, Belgaum for the year 1994-95. Mr. G. Babu. D'man III has provided computer assistance for making various drawings and graphics.

(S M SETH)

DIRECTOR

CONTENTS

Sl No.	Description	Page
	Preface	i
	Contents	ii
	List of Tables	iii
	List of Figures	iii
	List of Appendices	iii
	Abstract	iv
1.0	**Introduction**	**01**
2.0	**Failure of Open Wells : A Review**	**02**
3.0	**Problem Definition**	**05**
4.0	**Study Area**	**06**
5.0	**Occurrence of Groundwater in Hukkeri Taluk**	**14**
6.0	**Pumping and Recovery Tests**	**33**
7.0	**Results and Discussion**	**49**
8.0	**Conclusion**	**59**
	REFERENCES	**60**
	APPENDICES	**61**

LIST OF TABLES

Sl. No.	Description	Page No.
1.	Annual Rainfall Distribution in Hukkeri Taluk	10
2.	Evaporation in Hidkal Dam Site	10
3.	Some of the well characteristics of the region	19
4.	Talukwise yearly Groundwater Recharge in MCM and Rainfall in m	31
5.	Comparitive Hydrological condition in Hukkeri Taluk	32

LIST OF FIGURES

1.	Location map of the region	7a
2.	Index Map of Ghataprabha Command Area	7b
3.	Annual Precipitation in Different Stations	8
4.	Location Map of the failed wells Test Plot	18
5(a).	Monthly Precipitation & Evaporation in Hukkeri	20
5(b).	Monthly Precipitation & Evaporation in Sankeshwar	20
5(c).	Monthly Precipitation & Evaporation in Hattargi	21
5(d).	Monthly Precipitation & Evaporation in Sarapur	21
5(e).	Monthly Precipitation & Evaporation in Hidkal	22
6(a).	Monthly Water Level in Hukkeri	23
6(b).	Monthly Water Level in Yadgud	24
6(c).	Bore Water Level Fluctuation in Hukkeri	25
6(d).	Bore Water Level Fluctuation in Hanchinal	26
6(e).	Bore Water Level Fluctuation in Yadgud	27
6(f).	Bore Water Level Fluctuation in Sankeshwar	28
6(g).	Bore Water Level Fluctuation in Hebbal	29
7.	Location of bore well extension data	30
8.	Time Drawdown plot of Tested Wells	34
9.	Inflow Theory for Hard Rock Open Wells	35
10.	Data Plot of Log S1/S2 of Tested Wells in Hukkeri Taluk	37
11a.	Well Litholog of Well No. 1	39
11b.	Well Litholog of Well No.2	41
12.	Best fit of C.S.Area Vs. Time taken for 99 % Recouperation	51
13.	Best fit of Well Depth Vs. Rock Permeability	51
14a.	Water Level Contours for Pre-Monsoon 1989	53
14b.	Water Level Contours for Post-Monsoon 1989	54
15a.	Water Level Contours for Pre-Monsoon 1990	55
15b.	Water Level Contours for Post-Monsoon 1990	56
16.	Artificial Recharge Measurer	58

LIST OF APPENDICES

APPENDIX A - VILLAGE WISE EXISTENCE OF WELLS

APPENDIX B - PUMP TEST RESULTS OF FAILED WELLS IN HUKKERI TALUK BY DEPT. OF M & G, BELGAUM

APPENDIX C - VILLAGE WISE EXPANSION OF BORE WELLS IN HUKKERI TALUK (PHE, HUKKERI)

ABSTRACT

Study of Failure of Open Wells in Hukkeri Taluk of Belgaum district in Karnataka State has been carried out. History of the ground water occurrence in the region has been reviewed as per the workdone by State Department of Mines & Geology in the year 1975 and then by Central Ground Water Board in the year 1980. Present situation is assessed through various analysis including Pumping and Recovery tests were carried out in a test plot, in a location were most of the failed wells have been noticed. Kumarswamy's method of calculating Well Rock Permeability has been preferred as against Transmissivity and Storativity. Permeability values ranges from 0.08 m/hr to 0.346 m/hr. Reasons for failure of open wells in the specific region have been discussed and remedial artificial recharge measures have been suggested. This being first study of its own type, methodology would be helpfull while sorting out same type of problem elsewhere.

1.0 INTRODUCTION

The history of open well construction may be traced back to (3000 B.C. to 800 B.C. for irrigation purposes and it has become an important source of irrigation water towards the end of Nineteenth century along with some localized use of ground water through open wells specially in places where lack of surface water resources exist. Though large scale development was started in 1934 but in mid Sixties it has become prime source for irrigation due to concurrent failure of monsoon in the various parts of the country, advent of high yielding varieties of wheat and rice, and the introduction of an incentive oriented agriculture pricing policy by the Government (Prasad, 1995).

Contribution of Groundwater to national water need can be appropriated through the available statistics. Half of the country's irrigation water requirement and a major part of domestic and industrial needs are being fulfilled by the subsurface water (Prasad, 1995). Use of open wells instantly got the emphasis due to its cheapness and simplicity of construction, operation and maintenance (Jain. 1977). As per the figure available by the end of march 1985, there were 8.726 million dug wells in the country and further 1.248 million dry wells were targeted during next five year plan, (CGWB. 1986). Lahiri (1975) estimated the draft through dug well as 71% of the total draft and Baweja (1979) stipulates the same figure as 79%. In Hard Rock Region of the country these wells are mostly used to tap ground water from shallow aquifers with low transmissivity and unconfined to semi confined aquifers. Over exploitation of ground water along with many other reasons in certain areas has resulted in progressive lowering of the water levels and consequent decline to the yield and productivity of wells, which needs thorough study.

2.0 FAILURE OF OPEN WELLS: A REVIEW

In general failure of open well can be attributed to three distinct categories:Quantitative , Qualitative or both. Quality failure occurs when ample groundwater storage is available but can not be utilised for various purposes due to excessive chemical, biological contaminants. Quantitative failure is the outcome of the disbalance between yield and human exploitation of ground water. Here the concept of safe yield is introduced.

Safe yield is defined as the amount of water which can be taken from the aquifer indefinitely without producing an undesirable result, hydrologically it is almost the water which under normal circumstances leaves the basin as a natural base flow. Exploitable groundwater resources are closely linked with safe yield. It can be a maximum value close to the live storage, and are limited only by the technical problem of setting an adequate system of bore wells to utilize the groundwater to the maximum value or it can be actually exploitable groundwater resources governed by technical, environmental and legal requirements on the minimum baseflow and or minimum groundwater level. Undesirable results occur when the ground water storage can not be replenished by a natural recharge in a reasonable period of time, or when a prolonged abstraction results in the intrusion of saline water, or in deterioration of water Quality.

A pumping test is a controlled field experiment to find out the hydraulic characteristics of an aquifer or the yield characteristics of well. Aquifer parameters, namely transmissivity (T) and storativity (S), are determined by analysis of the pumping test data. Two types of tests are generally used i.e., steady-state and non-steady state test. In a steady-state test, a well is pumped long enough so that the drawdown become reasonably constant. Theim's equation (1906) is used for calculating transmissivity of a confined or unconfined aquifer as the case may be. However, Theim's equation does not yield the value of storativity. Storage coefficient can be determined using nonsteady-state flow equation or other procedure given by Lohman (1972).

In a non steady-state test a well is pumped at a constant rate and drawdowns are recorded at various time intervals. The data so recorded are then used in determination of not only the transmissivity but also the storativity of the aquifer. In case of a non-leaky homogeneous and isotropic artesian aquifer with fully penetrating, small-diameter wells, methods devised by Theis (1935), Cooper and Jacob (1946) and Chow (1952) are widely used to determine T and S from nonsteady-state pumping test. These methods are based on graphical procedures. Large-diameter wells, being most appropriate ground water structures in hard rock areas, are difficult to be analyzed by these methods due to large contribution of storage and boundary conditions imposed by seepage face etc.

In hard rock areas, the large diameter wells are generally shallow and penetrate the weathered or intensively fractured layers. In these areas, the hydraulic conductivity of the unconfined aquifer generally decreases with depth and the wells are mostly fully penetrating. Most of the inflow into these wells is lateral through the wells. In alluvial areas the wells are generally partially penetrating and flow may be both lateral and from the bottom.

Slichter(1906) considered the case of a large diameter well having vertical impervious well steining and in which the flow is only from the bottom. Due to lack of theoretical validity, the specific capacity of the well calculated by this method cannot be used as the specific capacity determined by the method of Theis etc (Samuel, 1974). Muskat (1937) extended the use of Slichter's equation for estimation of transmissivity by causing it with the Theis solution(1906) for steady state flow. This equation can be applied only for dug wells tapping confined layer. However estimation of the distance to a point of zero drawdown may lead to serious errors.

Kumaraswamy(1973) observed that the conventional methods of determining the transmissivity and storativity cannot be applied in hard rock areas because of their anistropy and occurrence of flow in the well through pressure planes and conduits. He felt that open wells in hard rock have appreciable storage capacity, low inflow and no formation of cone of depression during pumping. Therefore he recommended following parameters to be determined during pumping test on open wells in hard rock areas. (1) Hard Rock Well Permeability (2) Maximum Inflow Capacity of Well (3) Time taken for 99 % recuperation.

Papadopulos and Cooper (1967) were the first to present a type-curve solution technique for the analysis of test data from large diameter wells with storage in confined aquifer. In recent years keen interest has been evinced for obtaining solutions to this problem of ground water flow towards large-diameter wells. Boulton and Streltsova (1975) produced type-curves for the early drawdown phase for partially penetrating large-diameter wells in unconfined aquifers having both compressibility and water table storage capacity. The works of Zdankus (1984) Rushton and Holt (1981) and Rushton and Singh (1984) are of particular significance in this regard. These methods rely heavily on graphical procedures and are, therefore, subject to errors of judgment. An even greater disadvantage lies in their inability for computer aided solutions.

Though computer oriented methods have been developed and reported by Saleem (1970), Labadie and Helweg (1975), and Rushton and Chan (1977) for analysis of pumping test data, these have not been used widely due to complexity of the procedures involved. Jat et. al.(1993) made attempt to determine transmissivity and storativity of an unconfined aquifer using ratio to trend method utilising pumping test data. Patel & Mishra (1983) analysed this steady flow to a large diameter well by a discrete Kernel approach. Analytical solution for time variant pumping has been sought, in case of unsteady flow to a large diameter well using discrete Kernel approach by Mishra and Chachadi (1985 & 1988). They also provided background for deciding optimum depth and diameter of open wells in hard rock regions.

There are quite a few literature available on performance of open wells in hard rock regions. Krupanidhi et. al(1973) studied the specific capacities in Mysore state. Raju et. al (1985) studied the specific capacities in Himayatnagar, Ranga Reddy district, Andhra Pradesh. Raju (1979) checked the performance of dug wells in Mahaboobnagar district of AP. Viswanathaiah et.al (1978) found specific capacity of wells in some hard rocks in Karnataka. Rao et. al (1991) compared the specific capacities of large diameter wells in different terrains of crystalline rocks in Southern part of India using Slichter's formula (1956). All these works concludes a similar conclusion that specific capacity increases with increase of cross sectional area of wells and permeability decreases with increase in depth beyond 5.5 m from the ground surface.

Most of these approaches are limited to more of a scientific research for specific field conditions and as such yet to be verified for hard rock region. Selection for method of analysis for pumping test data is of prime importance, so that the estimated parameter should yield to more general representation of groundwater flow and balance of the hydrological basin rather than confinement to preferred values. The need arises therefore is to check the synthesis of every parameter emphasized in various concepts through sensitive analysis, as in the recent work done by Jino and Rushton(1995), on various regions to see whether infact there can be any generalised practice of parameter selection in hard rock region and most critically to what scale.

3.0 PROBLEM DEFINITION

Based upon the above literature review it has been decided to study the failure of open wells in the Hukkeri Taluk of Belgaum district of Karnataka state. In the present study existing details of the region has been collected along with the detailed study of the ground water resources in the region previously carried out by state department of mines and Geology in year 1975 and again by Central Ground Water Board in the year 1980. Nine pump tests were carried out in selected wells for small area inside the region to assess the present level of performance of these wells using Kumaraswamy's method of pump test data analysis. The reason for failure of these wells are analysed and possible measures for artificial recharge has been discussed.

4.0 STUDY AREA

4.1 Location :

Hukkeri taluk which is located in the north-western part of Belgaum district, covers an area of 990.25 sq km and lies between longitude : 74° 19'30" and 74° 46'10" and latitude : 15° 57'40" and 16° 21'45" forming part of Survey of India toposheets no. 47 L/7, L/8, L/11, L/12 and 48 I/9. Hukkeri town which is the taluk headquarters , is located about 54 kms north-northeast of Belgaum (Fig.1). Topographically the area is much undulating consisting of extensive flat topped plateau and rounded hills with intermittent valleys. The region forms a transition between the hilly western ghats and greater plains to the east. The average elevation of the ground varies from 615m to 840 m above MSL.

4.2 Physiography :

Ghataprabha river with its major tributaries namely Hirenyakeshi and Markandeya forms the chief drainage for the area. Ghataprabha river enters the taluk at the south - western part of the taluk and flows northeast taking its course over quartzite valleys in the west and over-trap in the north-eastern part. Hirenyakeshi river flows in the central part of the taluk in the direction of east and drains into Ghataprabha near Ingli village. Markandeya river forming the south-eastern boundary of the taluk flows from southwest to north-east and ultimately drains into Ghataprabha in Gokak taluk. The valleys carved by the minor as well as the major drainage systems are shallow.

Following table gives details of basins and sub-basins in the taluk.

Basin / Sub basin	Extent in Hectares	Basin / Sub basin	Extent in Hectares
Hirenyakeshi		Ghataprabha	
Sollapur halla	11501.88	Doddahalla	6358.9
Kapurodha halla	8471.88	Hattargihalla	1292.80
Jabapur halla	5037.88	Doddihalla	2740.73
Sankeshwar halla	2735.88	Agsirihalla	4225.84
Masarguppi halla	3361.28	Kodihalla	5700.44
Khanapur halla	2376.32	Dugdhalla	3666.70
Yarnai halla	2011.51		
Gulabsha halla	2973.44		
Medihalli	1809.83	Other minor tributaries	3922.03
	40280.00		27907.44

Source : Department of Mines and Geology

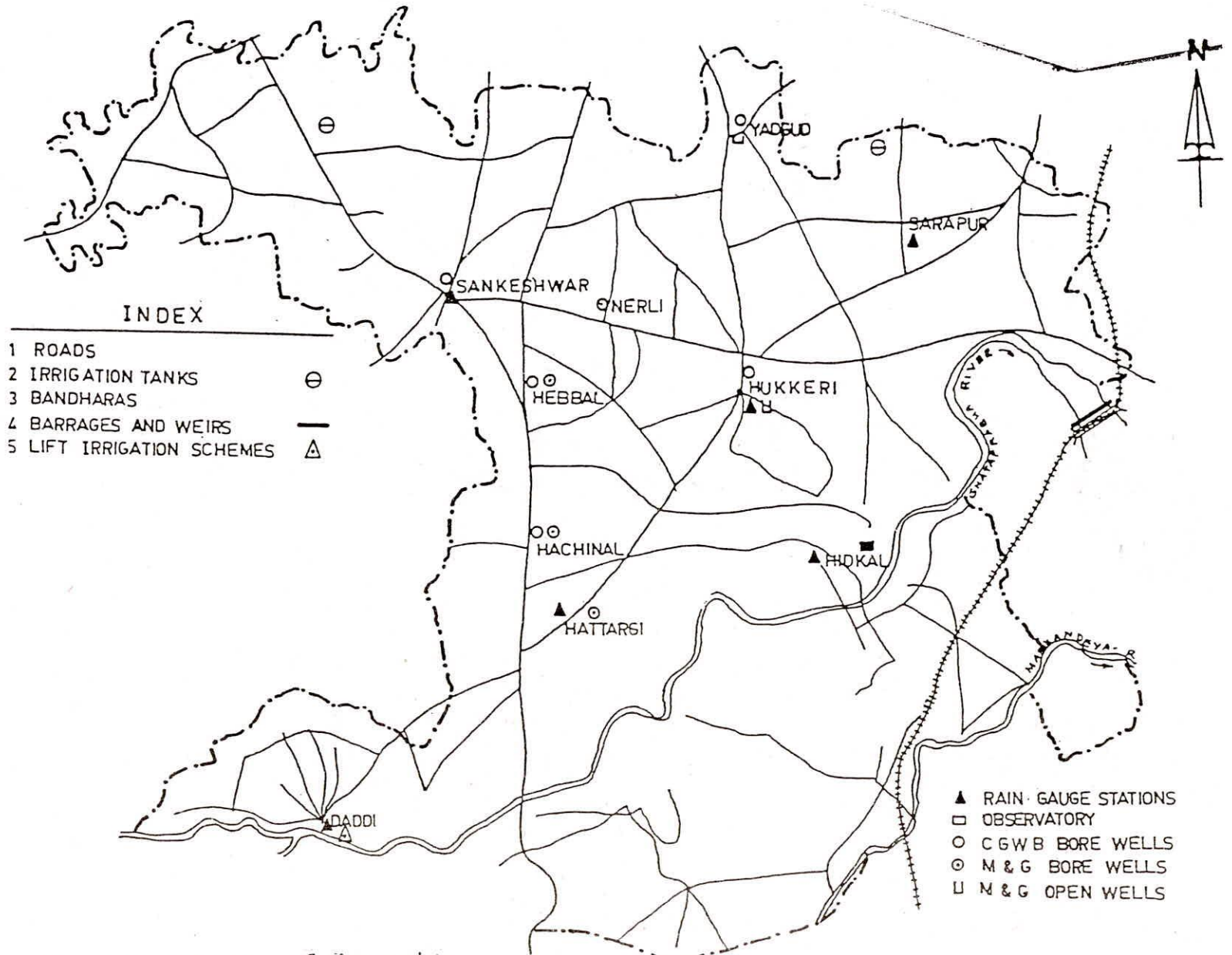

Fig. 1.Location Map of the region.

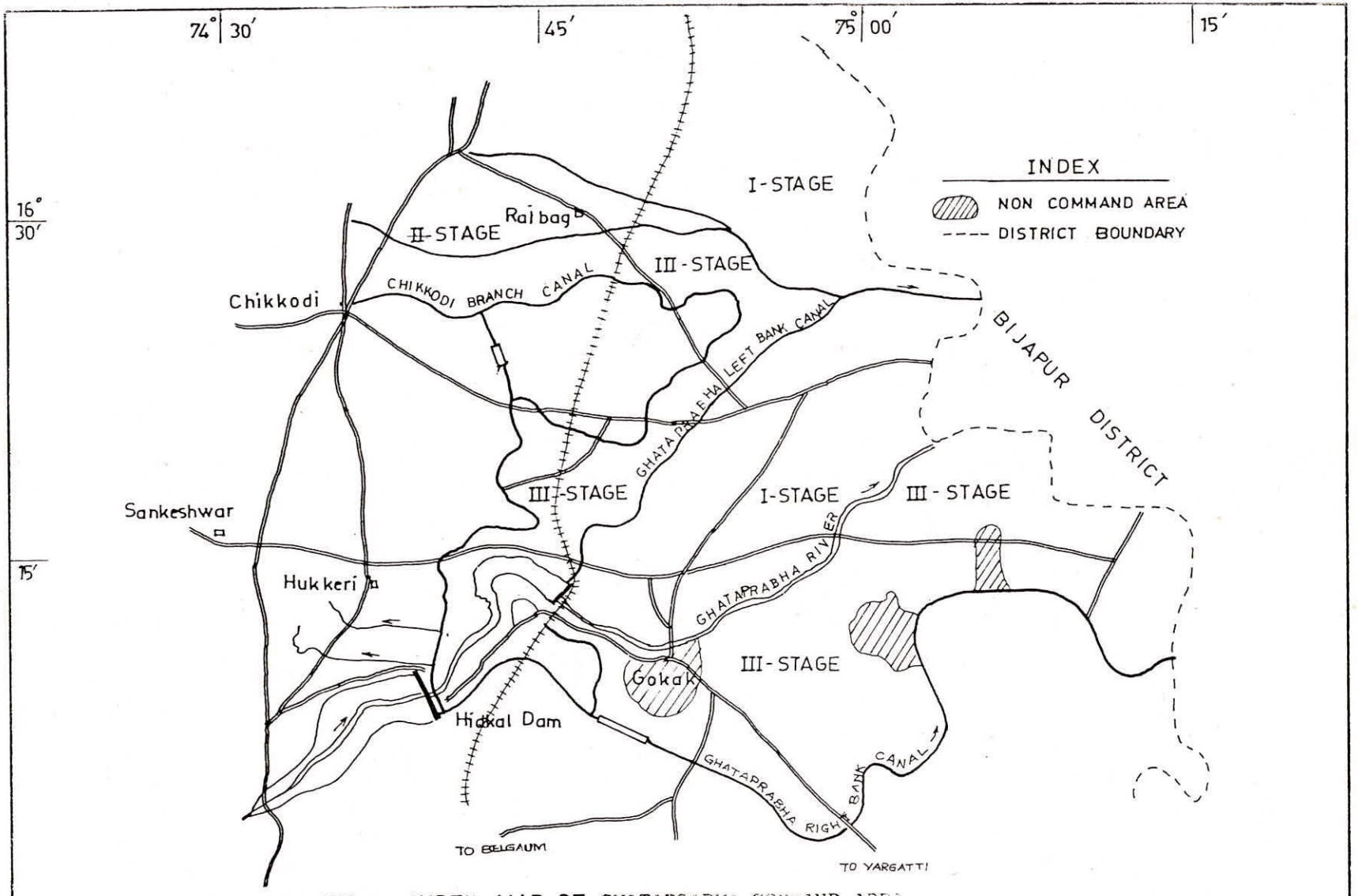

FIG.2. INDEX MAP OF GHATAPRABHA COMMAND AREA.

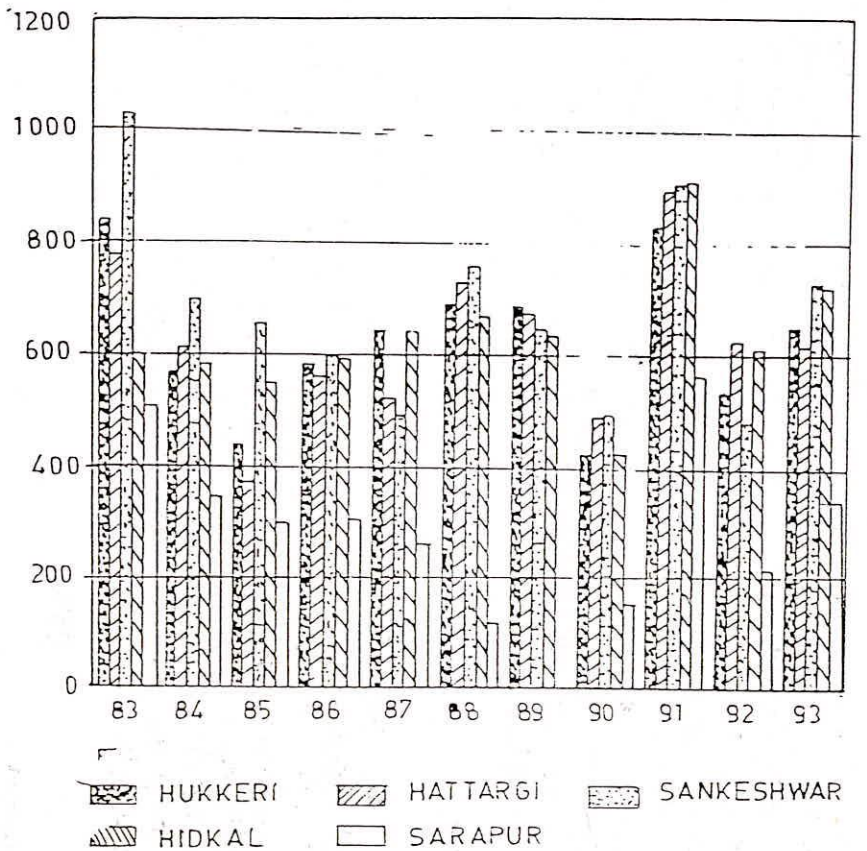

FIG. 3. ANNUAL PRECIPITATION IN DEFFERENT STATIONS

4.3 Meteorology :

Meteorological data indicates that the area experience rather hot summer and mild winters. The summer temperature during April - May reach as high as 42 C and the minimum may as low as 8 C in December - January. However the mean maximum may vary between 35 C and 37.5 C and the mean minimum varies round about 10.7 C. The western part of the taluk forms the Malnad tract with comparatively higher rainfall, passing on towards east to semi-arid tract. The western part is covered by evergreen forests as compared with the bare flat-topped hilly terrain to the east. The climate is cool and pleasant.

South-west monsoon sets in May and lasts upto October. July to October are the months experiencing the maximum rainfall. The heaviest rainfall generally occurs in the month of July. There are six raingauge stations available within the region. They are Hukkeri, Sankeshwar, Hattargi, Hidkal dam site, Daddi and Sarapur fig.1). Yearly rainfall pattern for the period 1983 to 1993 has been depicted in figure 2. Maximum annual rainfall recorded as 1277.7 mm in Daddi in the year 1983 and minimum rainfall has been recorded as 11 in Sarapur in the year 1988. Average rainfall over the region is 600 mm to 700 mm. The coefficient of variation for this eleven years data sequence comes out to be 0.21, 0.24, 0.22, 0.18, 0.27, 0.43 for Hukkeri, Sankeshwar, Hattargi, Hidkal dam site, Daddi, and Sarapur respectively. Except Sarapur variation is almost same in all other stations. These are depicted in Table 1. There is only one meteorological station available in the region that is Hidkal Dam Site. Average annual evaporation is 2301.06 mm as shown in Table 2 which is more than the average precipitation values.

4.4 Soils :

Major part of the Hukkeri taluk is covered by black to red soils. Black soils are derived from the trap basements. However, the thickness of the soil varies from 0.5 m to 1.5 m in some places. Red loamy sandy soils are mainly seen in the southern part of the taluk. Groundnut, tobacco and jowar are the major crops of the region. Sandy loam soils are widely distributed in the Hidkal area. Black soil varies widely in their grain size from pebble to clay. Clayey soils are quite sticky when wet and acts as an impermeable layer in some aquifers. Average rate of infiltration in the taluk (test conducted near Hidkal dam site) is 3 cm/ hour in the agriculture land (Purandara et al. 1994).

4.5 Geology :

Geologically the area can be divided into two units, the northern part consisting of mostly Deccan traps and the southern portion consisting of sandstones and quartzites of Kaladgis. Laterites capping the traps are exposed on hilly top near Hidkal. Basaltic lava flows which cover major northern part of the taluk are gray to black in colour and are hard, massive, compact with very few blow holes. This variety of trap is crisscrossed by vertical as well as horizontal joints. Vertical joints which are prominently developed at shallow depths have produced columnar structures which are seen spaced at 0.25 to 1 m apart and in some of the road cuttings the joints are seen spaced at 2 to 2.5 m apart. The weathering in this variety of trap is very rare and often limited to 0.5 m to 1m. Spheroidal weathering of traps is noticed at Sankeshwar, Chikalgud and other neighboring areas.

Table1 Annual Rainfall Distribution in Hukkeri Taluk.

ANNUAL PRECIPITATION IN DIFFERENT RAINGAUGE STATIONS								
Year	Hukkeri	Hattargi	Sankeshwar	Hidkal	Sarapur	Daddi	Mean	C.V.
1983	837.10	774.50	1027.40	596.40	503.60	1277.70	836.17	.30
1984	568.40	609.80	696.00	581.20	345.20	895.40	615.95	.20
1985	436.40	369.60	654.00	546.61	298.00	843.90	524.75	.30
1986	581.20	558.80	597.40	591.80	305.00	728.60	560.47	.20
1987	642.90	520.60	485.80	639.80	259.30	433.20	496.93	.20
1988	687.50	725.00	756.60	666.10	116.20	758.8	618.37	.30
1989	685.80	670.60	645.20	635.20		953.00	717.96	.10
1990	420.30	487.10	492.10	421.20	154.10	815.50	465.05	.40
1991	829.80	892.00	905.80	910.30	563.50	1270.30	895.28	.20
1992	534.60	624.70	478.80	615.10	215.00	941.00	568.20	.30
1993	653.10	617.40	730.00	722.10	341.00	1264.10	721.28	.30
Mean	625.19	622.74	679.01	629.62	310.09	925.59	638.22	
C.V.	.21	.22	.21	.18	.43	.27	.21	

Table 2

Evaporation in Hidkal Dam Site

Year	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	159.40	194.20	272.70	335.7	300.70	213.30	159.20	114.20	142.2	163.40	148.10	134.70	2337.80
1984	167.40	182.00	229.40	258.00	328.60	207.00	128.65	124.62	147.60	145.08	162.00	139.50	2219.85
1985	217.31	179.76	259.78	292.20	315.89	174.60	144.77	128.34	209.10	141.36	179.40	164.92	2407.43
1986	175.77	189.56	283.65	305.80	311.50	168.30	167.10	138.40	179.50	165.90	122.40	147.80	2355.68
1987	166.10	185.20	261.60	305.10	278.80	197.90	184.10	163.30	168.20	147.70	138.40	129.60	2326.00
1988	155.20	211.50	278.60	251.20	280.10	187.10	129.60	112.10	114.40	159.90	157.10	127.60	2164.40
Mean	173.53	190.37	264.29	291.33	302.60	191.37	152.24	130.16	160.17	153.89	151.23	140.69	2301.86
C. V	.12	.06	.07	.1	.06	.09	.13	.13	.19	.06	.12	.09	.04

Pink trap which can be commonly noticed at the north-west and north-eastern part of the taluk are having more amygdoloidal structures and blow holes which are filled with secondary minerals like zeolites and quartz. This trap, though rarely jointed is seen weathered up to 12 to 15 m depth. Patches of pink trap are noticed in massive black trap zone near Gudas.

Full thickness of quartzite bed cannot be visualized clearly as the beds are horizontal. A vertical section of the sandstone and quartzite exposure near Sutagatti measures roughly 150 m. Shale intercalations of 2 to 6 cms are very common in quartzite. The thickness of the bedding plane varies from few centimeters to 1 m. Sandstone / quartzites are medium grained in texture and vertical joints are spaced at 0.50 to 0.75 m interval and horizontal joints are spaced 0.25 to 1.50 m apart. Depth of weathering is hardly a few centimeter from surface.

4.6 Land Use and Agriculture :

Utilisation of land as per the data available for 1975, 1980 and 1993 are shown below.

Land Use	Year 1975 (As per Dept. of M & G)	Year 1980 (As per CGWB)	Year 1993 (As per Dept. of M & G)
Total Geographical extent of the taluk	99023.63	99025.00	99140.00
Area under forest	15005.00		13987.00
Proposed area under submergence cultivable area	13031.91		
Cultivable area	75218.00	75220.00	82417.00
Net area sown	69243.00	69240.00	68334.00
Uncultivable waste	9271.00		2736.00
Gross area irrigated by wells	1616.00	2422.68	
Total number of irrigation wells inventoried	3983	2669	
Total number of irrigation wells as on 1-1-1975	4073		8265

As per the Statistical Department the seasonal land and the cropping pattern in the area is furnished hereunder for the seasons 1984-85,85-86,86-87,87-88,88-89. Total area of the taluk is 991.40 sq. km:

No.	Particulars	84-85	85-86	86-87	87-88	88-89
1	Cultivated land	645.5	672.82	668.74	667.79	683.29
2	Fallow land	37.79	10.47	14.55	5.5	-
3	Noncultivated land	27.33	27.33	27.33	27.33	27.33
4	Forest land	139.87	139.87	139.87	139.87	139.87
5	Not available for agriculture	140.91	140.91	140.91	140.91	140.91

Cropping Pattern

No	Particulars	'84-85	'85-86	'86-87	'87-88	'88-89
1	Pulses	13.50	58.00	62.30	9.57	62.00
2	Groundnut	206.83	177.84	176.90	167.30	181.56
3	Jowar	171.63	168.46	163.68	169.1	197.52
4	Tur	0.89	10.01	9.50	12.67	11.55
5	Sugarcane	64.39	47.37	48.20	43.63	80.23
6	Cotton	0.73	0.55	1.18	0.54	9.14
7	Tobacco	42.47	38.27	39.60	40.60	39.69
8	Paddy	25.24	25.53	25.60	25.33	27.17
9	Ragi	8.00	7.00	2.85	1.20	2.50
10	Maize	12.46	9.01	9.46	11.41	23.91
11	Wheat	13.76	10.54	12.50	50.87	0.83
12	Millet	---	---	9.09	11.24	12.73
13	HYC	---	---	177.47	262.67	174.83
14	Gram	12.80	5.60	10.00	11.06	1.62

4.7 Surface Water Facilities :

There are no irrigation tanks existing in the area. A few percolating tanks are constructed at the initial catchment zones near Nerli. Shirahatti, Kudur etc. which are very minor and possess water only for few months in a year. It is expected that these tanks may help in raising the water table in the wells by percolation and prevent heavy surface run off. Detailed observation of the water table is necessary to study whether there has been over exploitation or otherwise.

Previously, a number of lift irrigation wells were sunk along the nalla course of Kapurdhahalla which was reported to be once perennial. But, consequently this nalla with its tributaries were completely dried up due to severe drought in recent years and heavy lifting of water and sinking of innumerable wells along the nalla course. Lift irrigation is being attempted to irrigate about 800 to 1000 hectares of land by utilizing the water of Hirenyakeshi river near Sankeshwar and under this scheme only sugarcane is being grown. The river Hirayanakeshi is observed dry for at least 4 to 6 months of the year.

Hidkal dam was constructed across the river Ghataprabha near Hidkal over quartzites, submerges 22 villages covering an extent of about 13, 032 hectares of land. It is expected that this dam influence wells considerably. The salient features of the Ghataprabha project is furnished below

1	Location of Dam	Hidkal village, Hukkeri Taluk, Belgaum District
2	Catchment Area	1411.6 sq. km.
3	Maximum Flood Discharge	4617.56 cumecs
4	Yield of Ghataprabha River at Dupdal	3426.35 MCM at 75% dependability
5	Water Utilisation under Ghataprabha Valley Development Scheme	2548 MCM
6	Gross Storage	1448.4 MCM
7	Effective Storage	1386.8 MCM
8	Bed level	614.17 M above MSL
9	Max. Reservoir level	662.94 M above MSL
10	Maximum water spread area	77.7 sq. km
11	Total Length of Dam	10,183.4 metres
12	Area irrigated	3.03 lakh hectares
13	Spillway gates	10 Nos 12.2m X 7.6 m Depth (Radial Type)
14	Length of the Right Bank Main canal	196.8 km
15	Length of the branches of the Right bank main canal	142.4 km
16	Irrigate command Right bank canal	1.61 lakh hectares
17	Length of the left bank main canal	113.6 km
18	Length of the branches of left bank main canal	148.8 km
19	Irrigate command left bank canal	1.42 lakh hectares

5.0 GROUNDWATER OCCURRENCES IN HUKKERI TALUK

The main source of recharge to groundwater body through atmospheric precipitation and to a little extent through infiltration of water from the streams during floods, and return water from irrigated lands. State department of Mines and Geology in 1975 and again Central Ground Water Board in year 1980 has carried out extensive survey and Ground water studies in the region. Results of their studies have been reproduced here for the background of the present study.

5.1 Work done by state department of Mines and Geology in year 1975.

5.1.1 Groundwater condition in the trap area:

5.1.1.1 Black trap:

This variety of trap is hard, compact and consists of few blow holes and are traversed by joints to shallow depth and as per the study of the existing wells and cores recovered from bore wells, the joint had persisted only up to 10 to 15 m depth below which, the rock becomes more and more compact and fresh. Presence of such massive variety of trap was noticed approximately from 630.6 m contour and below. Weathering extended hardly 0.50 to 1.0 m depth. As a result, the wells were sunk in considerable number in the depth range of 6 to 12 m. The wells so sunk were with the diameter of 6 m are noticed as mostly dry during summer and most of such wells were not being used. The water table in the wells located in massive trap were found at shallow depth during rainy season and found almost dry or contain little water during summer. Thus, the depth to water as per the inventory carried out varied from 2 to 10 m, in order to study the seasonal fluctuation of water table totally 6 wells were selected as conservation well and average fluctuation depicted as around 2.5m and 3.9 m during rainy and summer months respectively.

Totally, 14 pump tests were carried out in the wells located in such a trap zone. Wells located and in different topographical positions with varying depths and diameter that were selected to carry out such test and it was observed that the behaviour of black trap as a groundwater aquifer is very poor. The inflow rate in these wells varied from 0.27 to 2.8 litres per second.

5.1.1.2 Pink trap

Pink traps appeared to be a better aquifer. They are weathered to an average depth of 12 to 15 m and were having more blow holes and amygdoloidal structures which were filled by secondary minerals like zeolites and silica. More of fractures and fissures were noticed which helps to retain water percolation, after rainfall. Pink traps are seen at an approximate altitude of 660.6 to 675 m above M.S.L and extended approximately upto 630 m contour. Individual flows were differentiated by the presence of bole bed which appears to be a non pervious body. The wells sunk in pink traps were deeper and the depth range of wells varied from 20 to 16 m depending upon their topographical positions. The wells which were located in valleys showed better recuperation, pump test conducted are appended with the report which indicated the above. The depth to water table in such formations varied from 6 to 12 m depending upon the topography.

The revitalisation of shallow wells by sinking bore holes from the bottom of such wells had proved to be of much benefit in the traps of this area. During the course of survey, it was noticed that two wells belonging to Sriyuths Inamdar and Hussain sab at Nerli and Ammangi villages respectively were deepened by sinking bore holes of 6" dia to a depth of 57.66 and 108m. But however, yield tests were not conducted for the actual yield from the bores so drilled from the bottom of the wells. On an average, 1/4 to 3/4 hectare of land was being irrigated per well in this area.

5.1.2 Groundwater in Sandstone/Quartzites

Sandstone/quartzites were noticed in the southern part of the taluk. Even though these formations were fairly compact and non-porous, prominent joints were noticed were often intercalated by shale. The wells sunk in higher altitude had failed without yielding any water. Wells located in the valleys and where the formation is highly jointed, about 1 to 2 hectares of land was being irrigated under each well as could be seen in places like Daddi-Ramewad and Badakundri villages. Contact between trap and sandstone/quartzite were noticed in some of the well sections of Badakundri village near Hattargi-Hukkeri road at an approximate altitude of 620 m above MSL.

The open well sunk in quartzitic terrain were usually deep ranging in depth from 10 to 15 m and the water table on an average varied from 8 to 13 m. But the wells which were shallow, possessed little quantity of water or remain dry during acute summer.Hence, the deeper wells were preferable than large dia shallow wells in the area. Two bore wells drilled to a depth of 45.94 and 48.60m over sandstone/quartzites on the bank of Ghataprabha river in Hidkal camp had yielded 7.09 and 11.35 litres per second. This had substantiated the view that bore wells located in the favourable sections of the valley were successful than shallow open wells.

Totally 9 pumping and recovery tests were conducted in selected open irrigation wells in order to study the water yielding capacity of the formations in the area and salient features of the same are furnished in the Appendix 'A'. From the test so carried, it was clear that the total volume of inflow of water in wells range from 27.38 to 112.70 cu.m per day with an average of 79.43 cu.m per day. During the course of survey, it was noticed that there had been uneven concentration of wells without observing any spacing criteria, resulting in mutual interference and general water table going down over year especially in the northern part of the taluk. At this rate, if the well sinking programs are continued, it was feared that in distant future in major part of the taluk, the wells may go dry.

5.2 Work Done By CGWB In Year 1980

5.2.1 Deccan Traps

Ground water occurs under water table conditions in weathered and jointed traps, and under confined conditions on the zeolitic and vesicular traps wherever they are overlain by the hard traps. Depth of weathering in general varied from 2 m to 18 m. Wells ranged in depth from 3.7 m to 17.8 m bgl. and depth to water table ranged from 1.10 m to 16.2 m bgl. The yield of dug wells ranged from 20 cu. m /day to 250 cu. m/day for pumping period of 2 to 8 hours. Wells in valleys nearer to nallas and in zeolitic traps yielded better. A number of springs which are mostly seasonal in nature were found in the trap area. A number of bore wells of 150 mm diameter had been drilled by PHE Department to a depth of 90.8 m taping hard massive traps and also zeolitic traps. The yields of these wells range from 0.7 cu. m/h to 45.3 cu. m /h. Five yield cum recuperation tests were conducted on the open wells in the area to know the aquifer characteristics. The tests had given inflow rates in hard traps varying from 0.58 lpm/sq.m. to 1.2 lpm/sq.m. for recuperation period varied from 1380 minutes to 1175 minutes and in vesicular trap the inflow rates of 1.1 lpm/sq.m. to 1.2 lpm/sq.m. for recuperation period of 70 minutes and 1260 lpm. The transmissivity figures obtained by the Papadopulos and Cooper method ranged from 21.5 sq. m/day to 150. sq. m/day. The specific capacity of the wells ranged from 2.42 to 19.13 cu. m /h/m and unit specific capacity in the range of 0.039 - 0.1995 cu. m/ h/m. An interesting feature was that many of the wells in traps had struck water in the contact zone between traps and the underlying quartzites in the Hukkeri taluk and this forms a potential zone from the point of ground water development.

5.2.2 Quartzites/ Sandstones

Quartzites for the most part were horizontal but well jointed. Groundwater occurred under water table conditions in the joints and interstices. But in areas where quartzites occurred below the traps as in parts of Hukkeri taluk, ground water occurred under confined conditions along the contact zone. In other areas, the depth of weathering in quartzites exceed 20 m and wells ranged in total depth from 2 to 21 m and depth to water ranged from 0.6 m to 19.1 m bgl. The yield of wells tapping quartzites and sandstone ranged from 25 cu. m /day to 200 cu. m / day for a pumping period of 2 to 8 hours. Wells located in topographically low areas and situated in Perennial nallas yield better.

A number of bore wells were drilled by PHE department for rural water supply (mostly 150 mm dia) ranging in depth from 19.8 to 68 m giving yields ranging from 1.4 cum/hr to 40.95 cum/hr. These were used mostly for water supply. Yield test carried out on the open wells tapping quartzites and sandstone in the area had given inflow rates varying from 0.4 lpm/sq. m to 3.2 lpm/ sq. m for varying periods of recovery from 330 and 290 minutes. Transmissivity values ranged from 57 to 64 sq. m /day have been obtained by the Papadopulos and Cooper method. The specific capacity of two wells tested were 2.34 and 8.83 cu. m /h/m unit specific capacity in the range of 0.031 and 0.0143 cu. m/ h respectively. On an average, since the quartzites were well jointed, moderate yields can be expected.

The ground water which occurs in the weathered and fractured rock aquifers of the area was being developed for irrigation and domestic purposes mostly by the open wells and of late by bore wells. Most of the bore wells were being used for rural water supply only sunk by the minor irrigation and Public Health Engineering departments. Very few among these wells were fitted with motors. As per the available information there are 2849 dug wells out of which 2023 are energised with electric pump sets. Average annual draft being calculated as 24.93 MCM.

5.3 Present Scope of Analysis :

Hukkeri Taluk has 121 villages which are mostly relied upon the open wells for irrigation and upon the bore well for drinking purposes. Statistical figures of some of the villages near Hukkeri village is depicted in Appendix - B as provided by the state Department of Mines and Geology. Depth of open well ranges from 6 m to 25 m and depth of bore well mostly ranges from 40m to 110 m. Different details and the yearly fluctuations in last 8 years of some selected wells are shown in the following table 3.

On the basis of survey conducted by department of Mines and Geology, 15 villages recently have been detected where open well have failed. They are Belvi, Hanjanhatti, Shelapur, Shirahatti, Yadgud, Handigud, Amangi, Nidsoshi, Y.Munoli, Nerli, Kochari, Hattargi, Rakshi, Gudas and Ghataprabha. Moreover Pump and recovery tests have provided some of the more specific information in the Hukkeri Taluk. These details pertaining to failed wells have been depicted by Appendix C. Depth of these ranges from 9 m to 15 m, (Fig.3).

Rainfall is the main source of ground water recharge Rainfall pattern reveals that nearly 70 % to 80 % of the rainfall occurs during the southwest monsoon that is June to September. Rest is fed by Northeast monsoon months and winter and summer shower. Annual arithmetic mean rainfall on the basis of 11 years data (1983 to 1993) comes out to be 638.22 mm therefore the region can be stated to be semi arid regions. Against this normal rainfall yearly evaporation reaches to a comparatively higher value of 2302.06 mm.

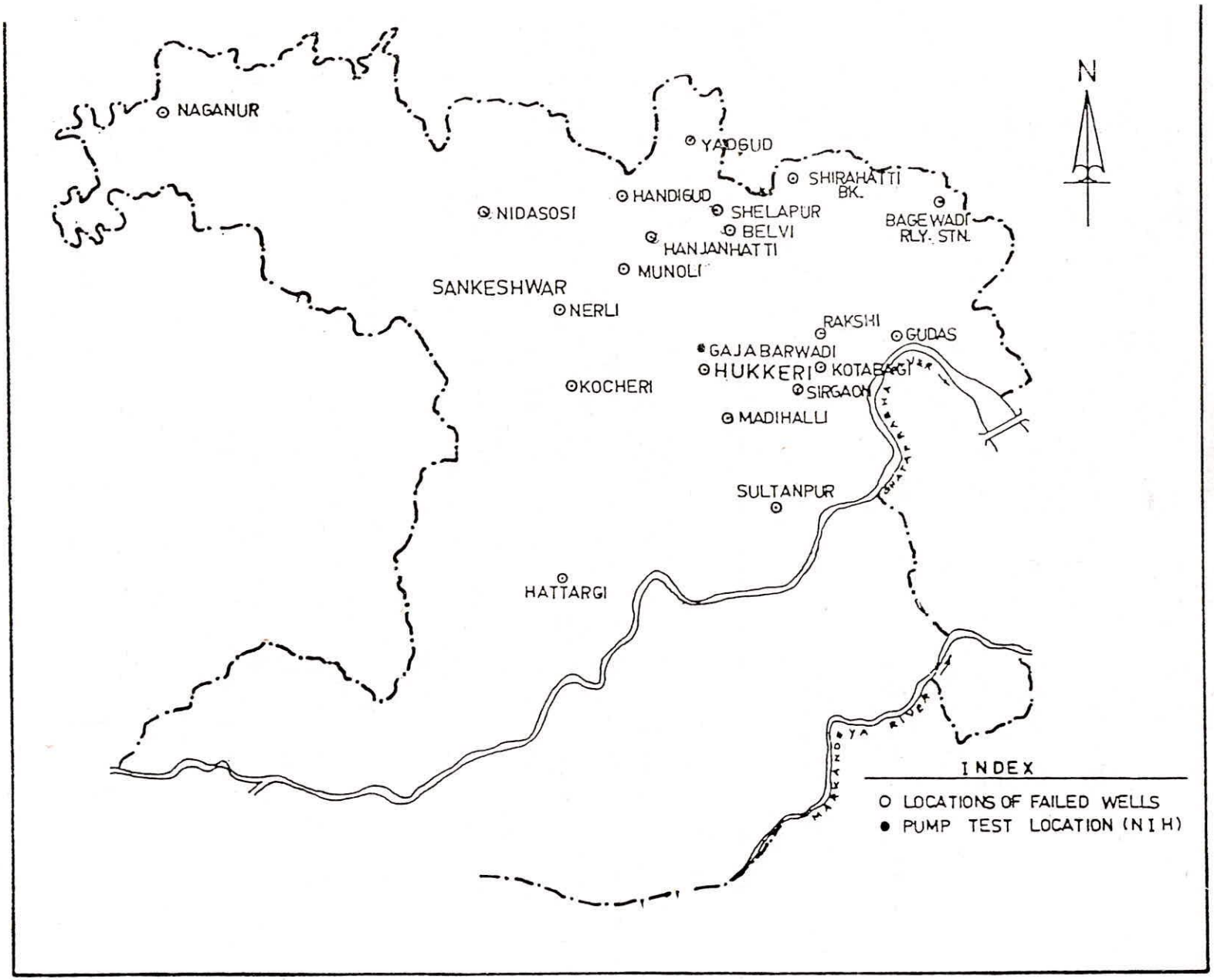

FIG. 4. Locatich map of the failed wells Test Plot

Table 3. Some of the Well characteristics of the region.

Village	Type of Well	Depth SWL (metres)	Size (metres)	Sp. Yld Yield	Water Max	Level Min (metres)	Fluctuation Average
Hukkeri	Dug	8.14	---	0.02	6.05 (1991)	1.30 (1990)	3.70 (1986-93)
Yadgud	Dug	21.80	3.78 (Dia)	0.02	14.70 (1991)	0.66 (1987)	5.26 (1986-93)
Hebbal	Bore	45.00 8.00	0.1143 (Dia)	25 gph	5.65 (1989)	2.14 (1989)	3.97 (1986-93)
Hattargi	Bore	42.00 10.00	0.1143 (Dia)	50 gph	8.5 (1986)	1.6 (1990)	5.13 (1986-90) (Collapsed)
Hanchinal	Bore	106.00 15.00	0.1143 (Dia)	75 gph	7.64 (1988)	3.06 (1986)	4.95 (1986-88) Collapsed
Nerli	Bore	45.00 NA	0.1143 (Dia)	---	10.30 (1988)	2.52 (1986)	6.41 (1986-88) Collapsed

To study the monthly balances out of rainfall, the monthly precipitates values for a particular R. G. stations for the years of maximum and minimum rainfall during last 11 years are plotted with corresponding monthly evaporation values of Hidkal dam site. This exercise has been carried out for 5 selected R.G. Stations namely Hukkeri, Sankeshwar, Hattargi, Sarapur and Hidkal dam site. In general it has been found that excess rainfall is available during the month of June, July and August. Which is being exploited in all other months where evaporation is more than the rainfall. All these details are depicted wide barcharts shown in fig 5a to 5e. Monthly water levels of some of the bore and dug wells in some of the selected years have been depicted in fig 6a to 6g. In open wells water table starts declining from February onwards and reaches deepest in May-June, thereafter it is being replenished through rainfall recharge mainly. In bore wells no specific trend is available as it depends entirely on recharge and discharge through out the year.

One of the most believed reasons for the failure of open wells have been over exploitation of groundwater through bore wells. Therefore sinking of some bore wells in some of the villages around Hukkeri Village (Fig.4) have been collected from Public Health Engineering department of Taluka parishad. Crucial informations are tabulated in the form of Appendix D. These wells are being used for drinking and other household purposes only. These informations projects a clear picture of expansion of bore wells in the region during last 8 to 10 years.

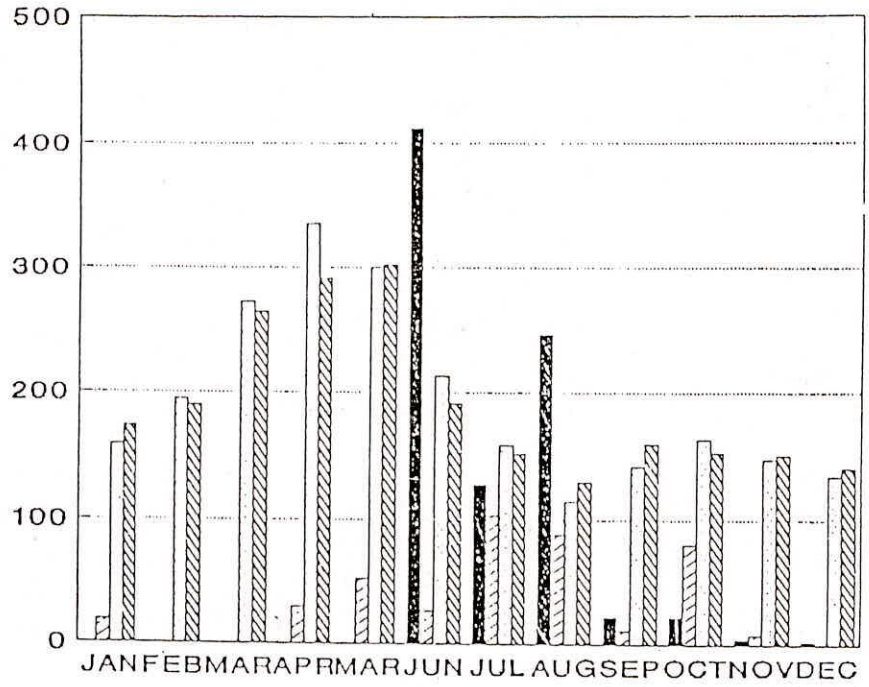

FIG.5a;MONTHLY PRECIPITATION & EVAPORATION IN HUKKERI

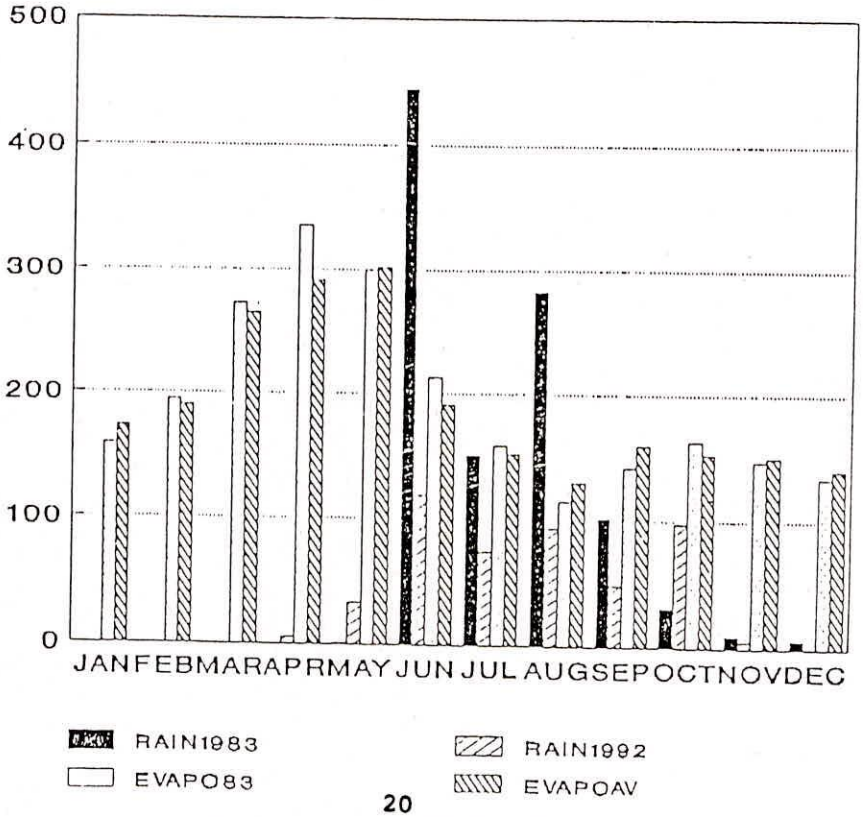

FIG 5b, MONTHLY PRECIPITATION & EVAPORATION IN SANKESHWAR.

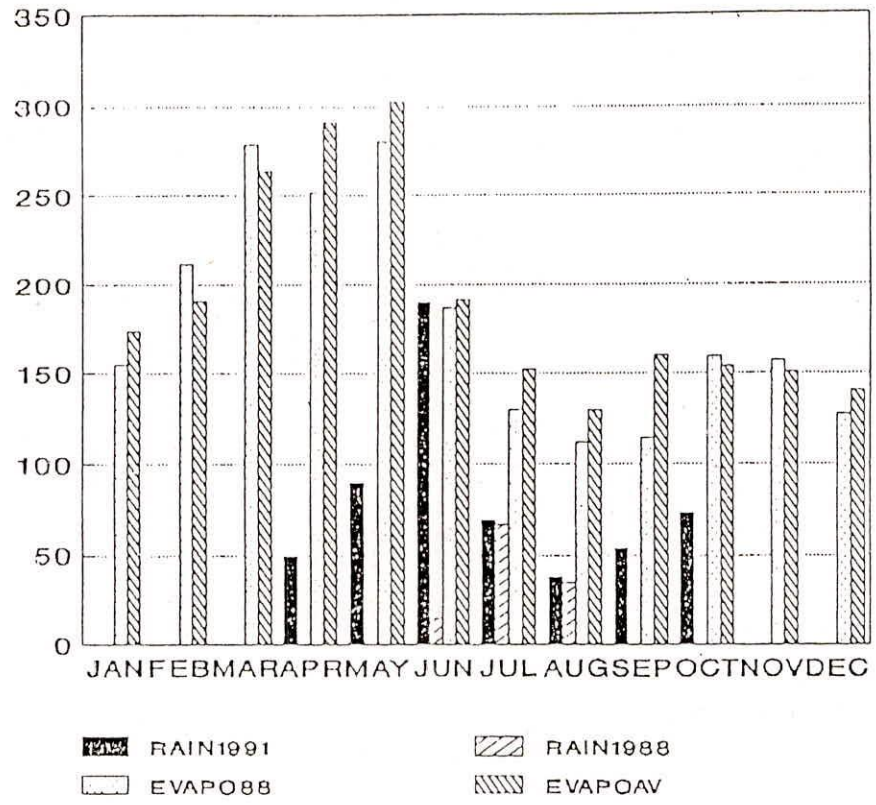

FIG54:MONTHLY PRECIPITATION & EVAPORATION IN SARAPUR

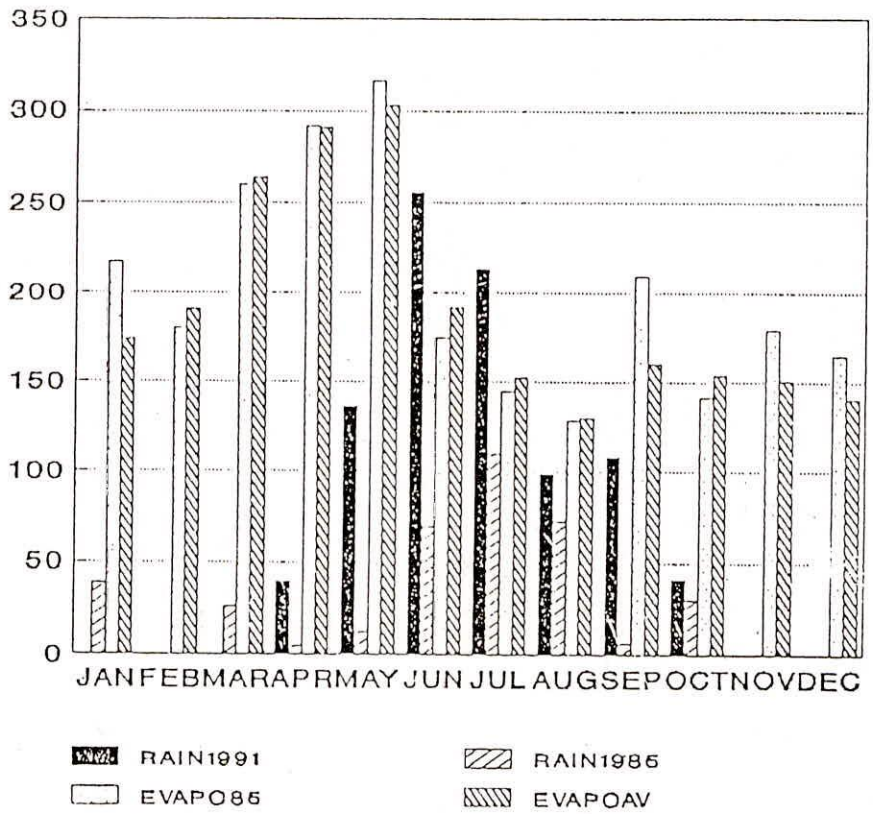

FIG55:MONTHLY PRECIPITATION & EVAPORATION IN HATTARGI

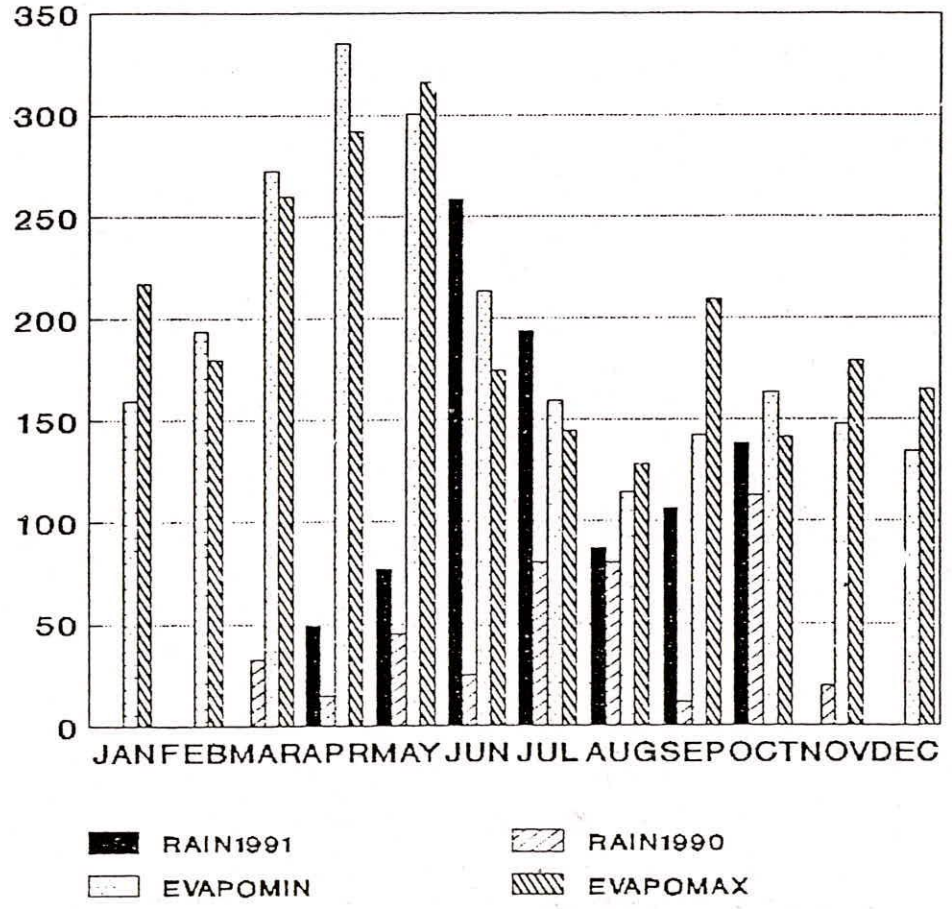

FIG 5: MONTHLY PRECIPITATION & EVAPORATION IN HIDKAL

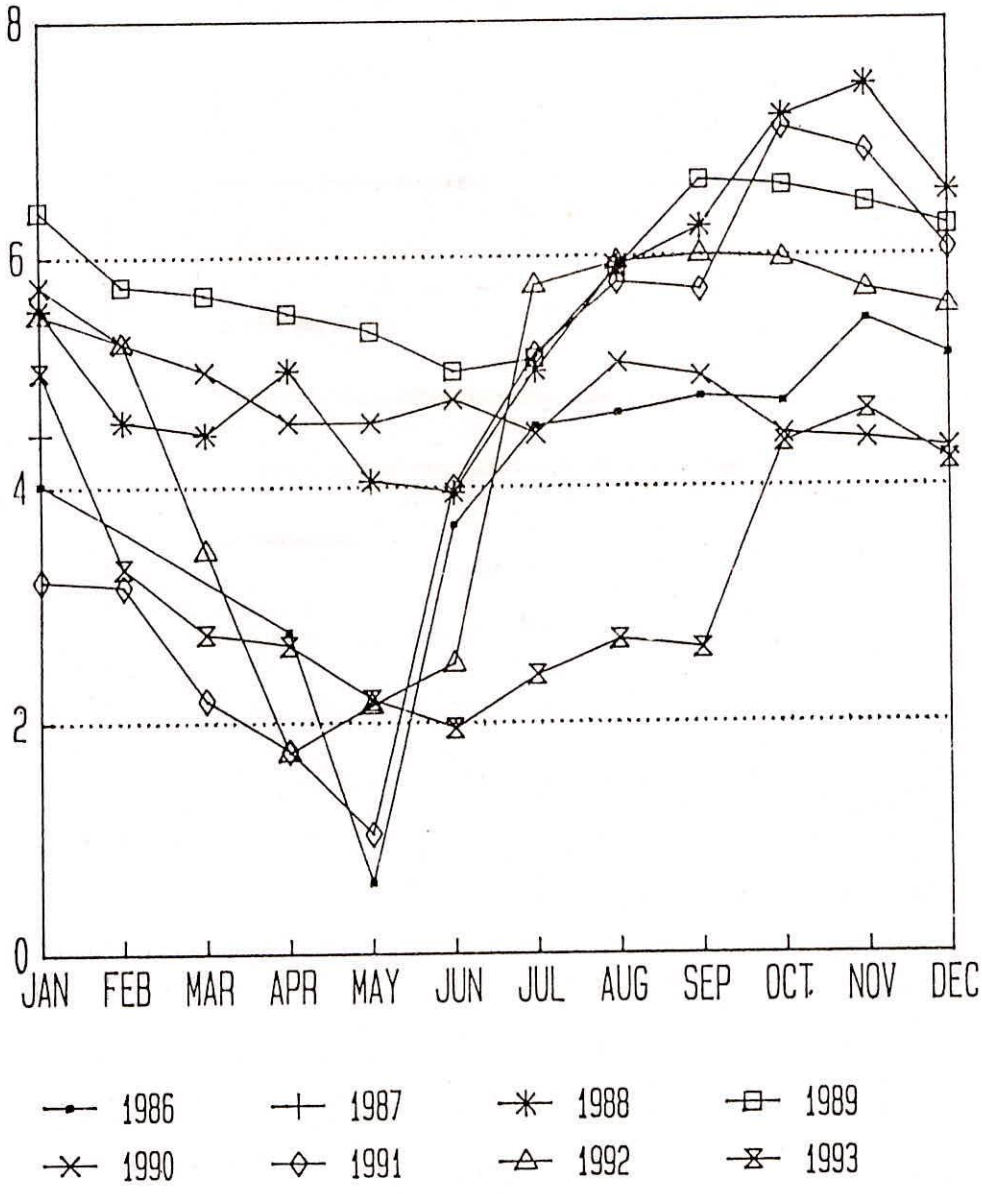

FIG.6a: MONTHLY WATER LEVEL IN HUKKERI

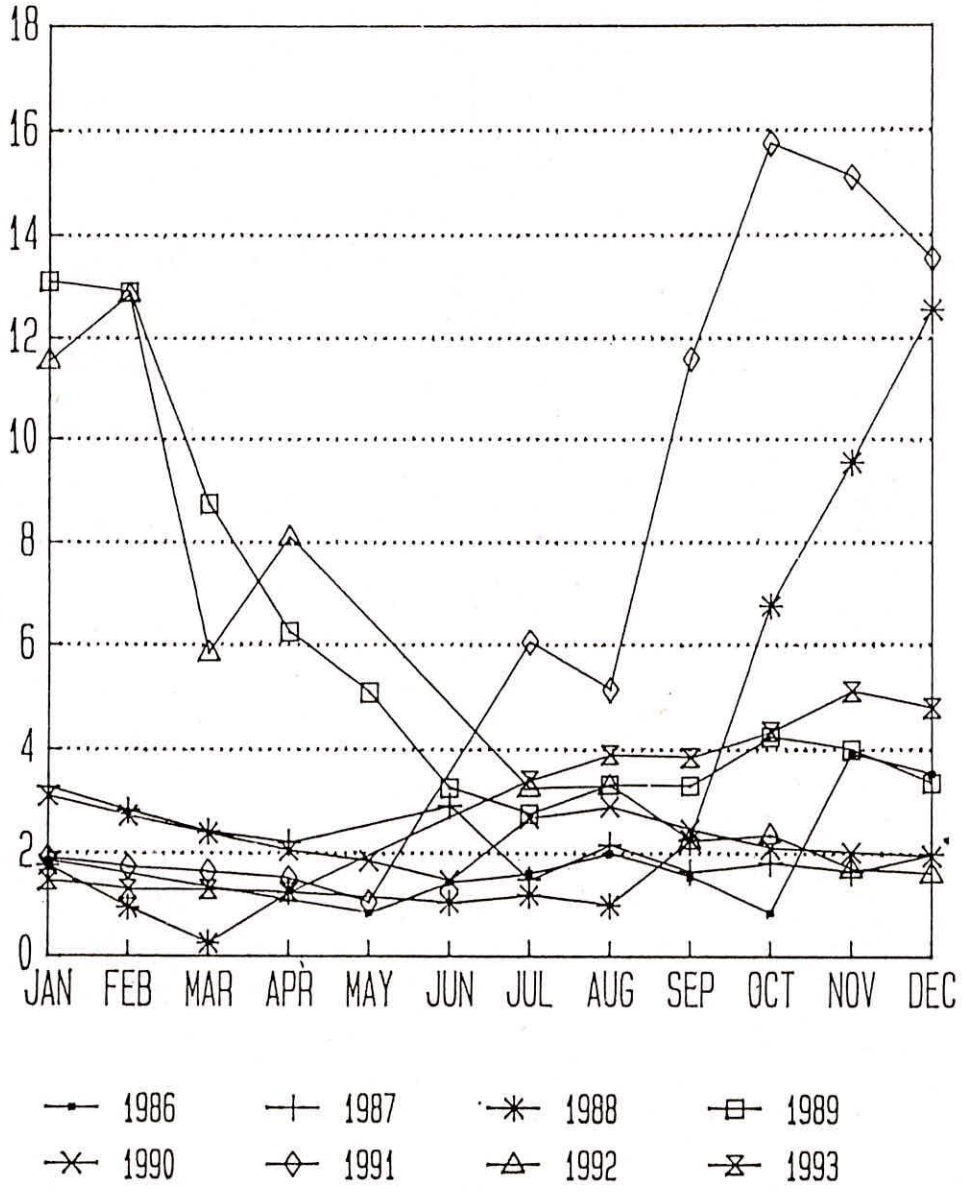

FIG.6b: MONTHLY WATER LEVEL IN YADGUD

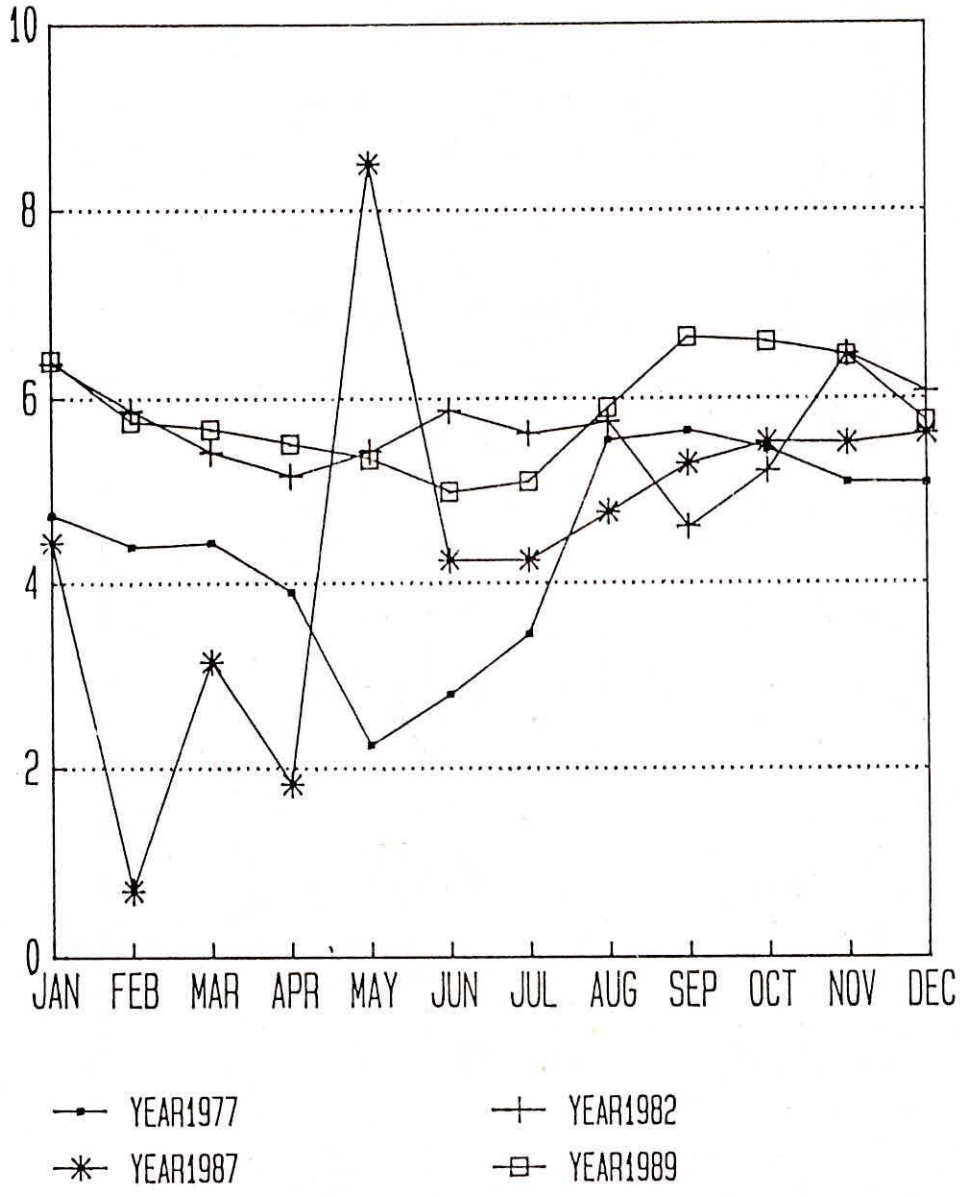

FIG 6 BORE WATER LEVEL FLUCTUATION IN HUKKERI

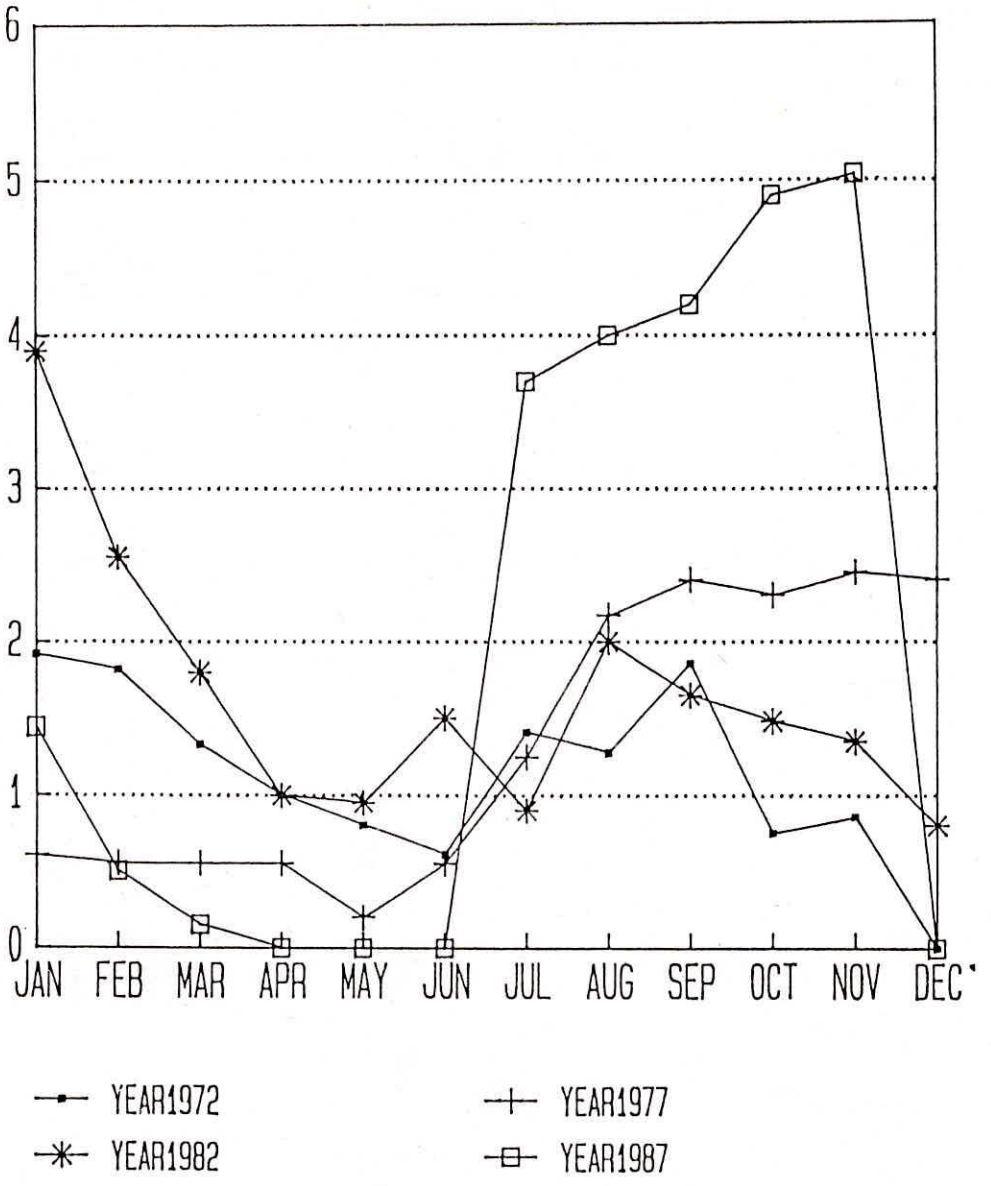

FIG6d: BORE WATER LEVEL FLUCTUATION IN HANCHINAL

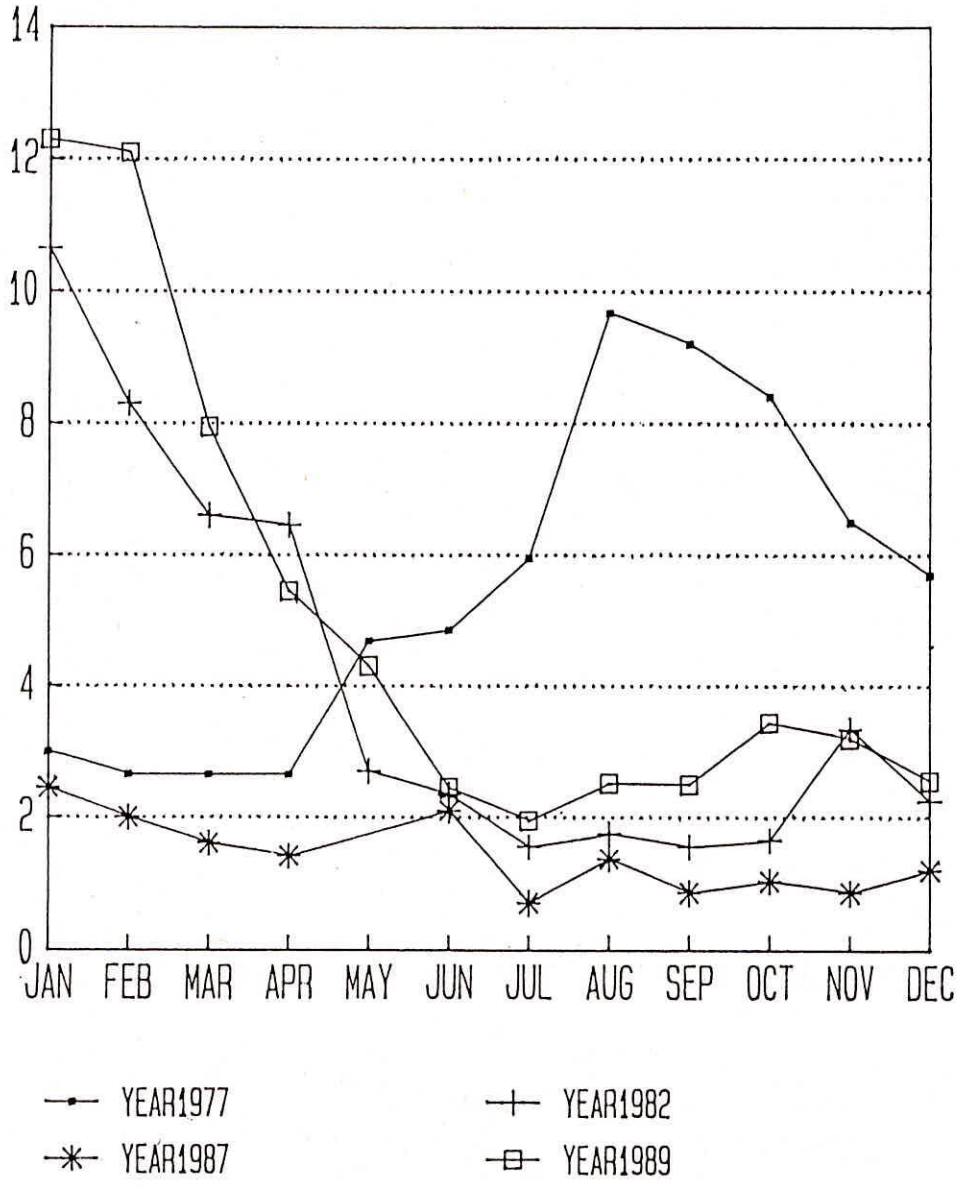

FIG6: BORE WATER LEVEL FLUCTUATIONS IN YADGUD

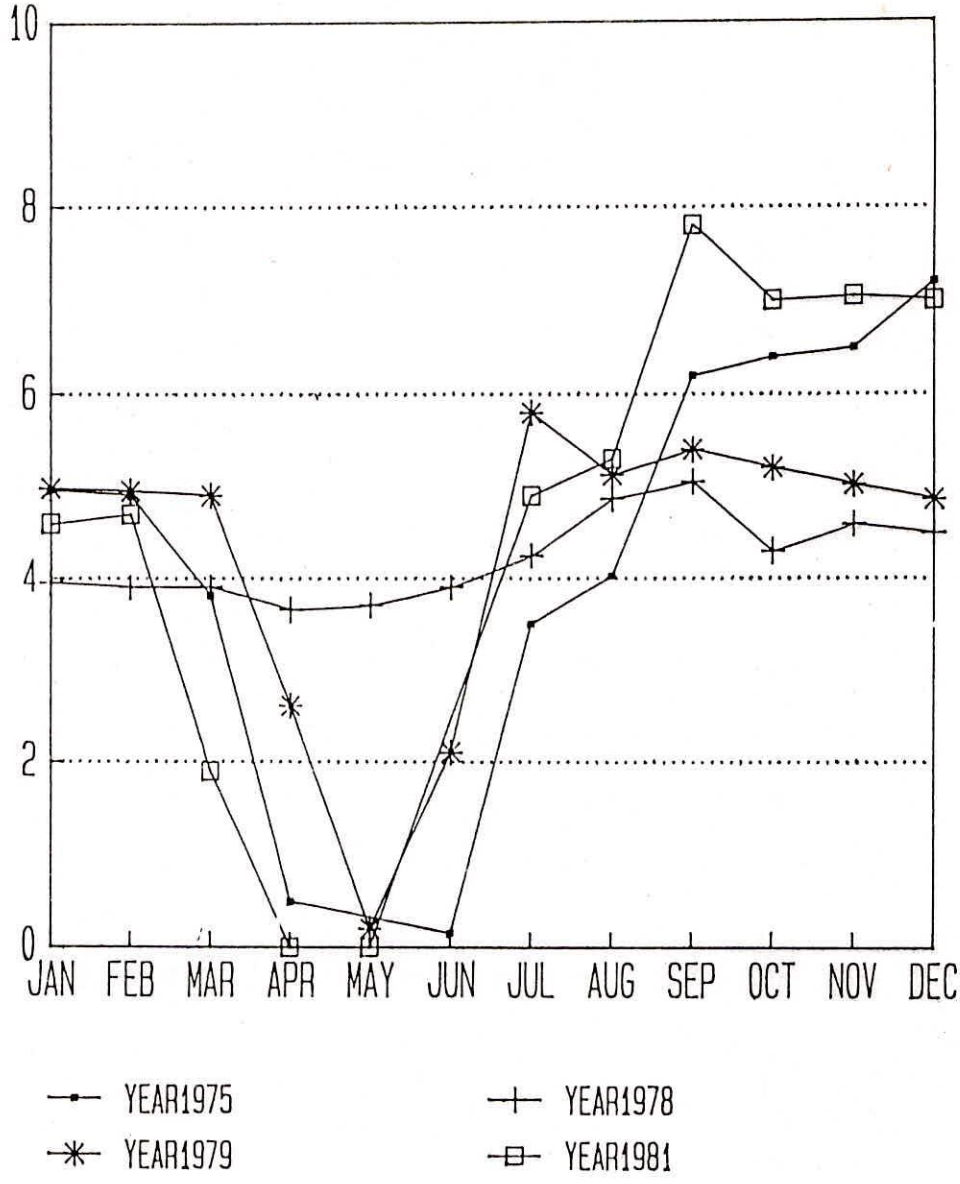

FIG6f: BORE WATER LEVEL FLUCTUATION IN SANKESHWAR

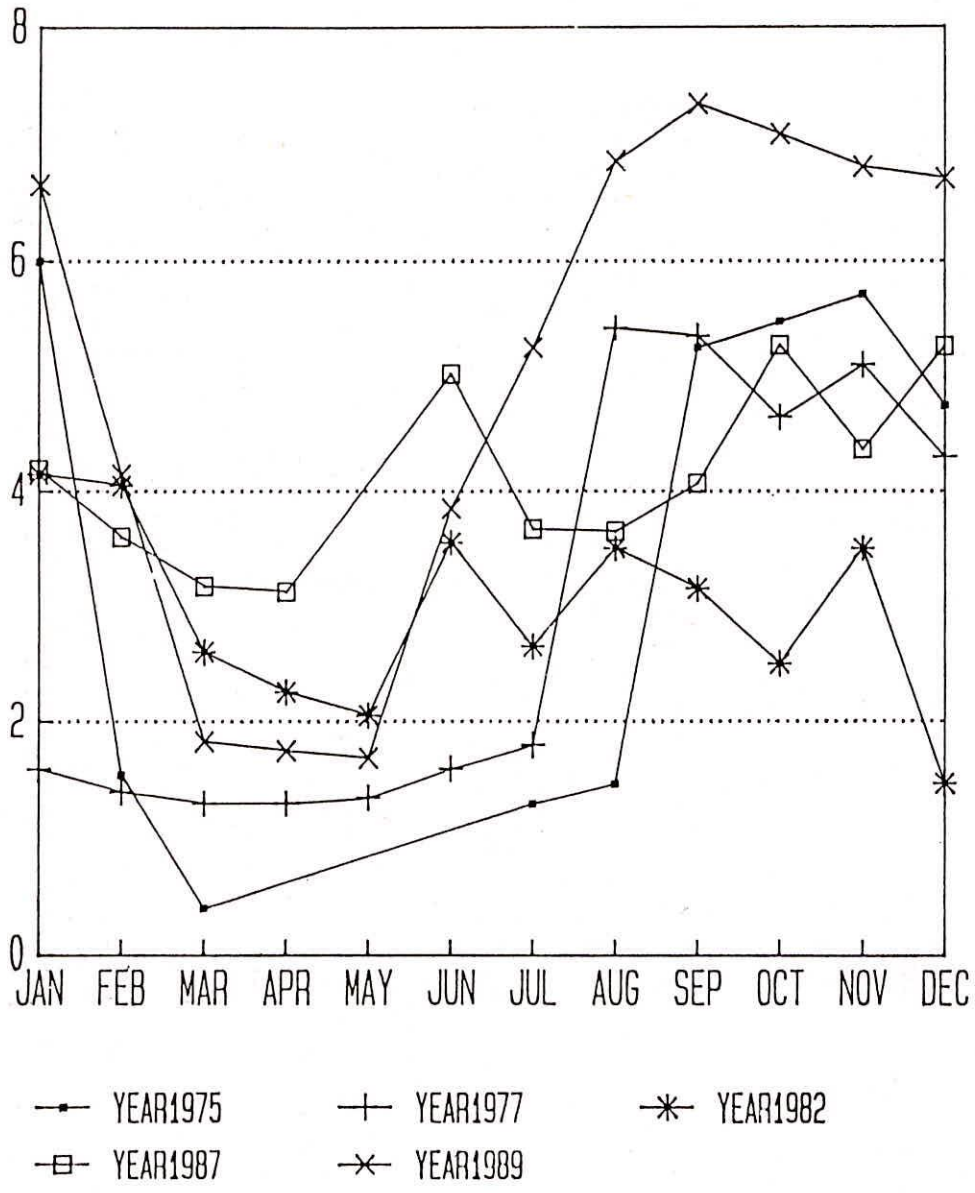

FIG 6g BORE WATER LEVEL FLUCTUATION IN HEBBAL

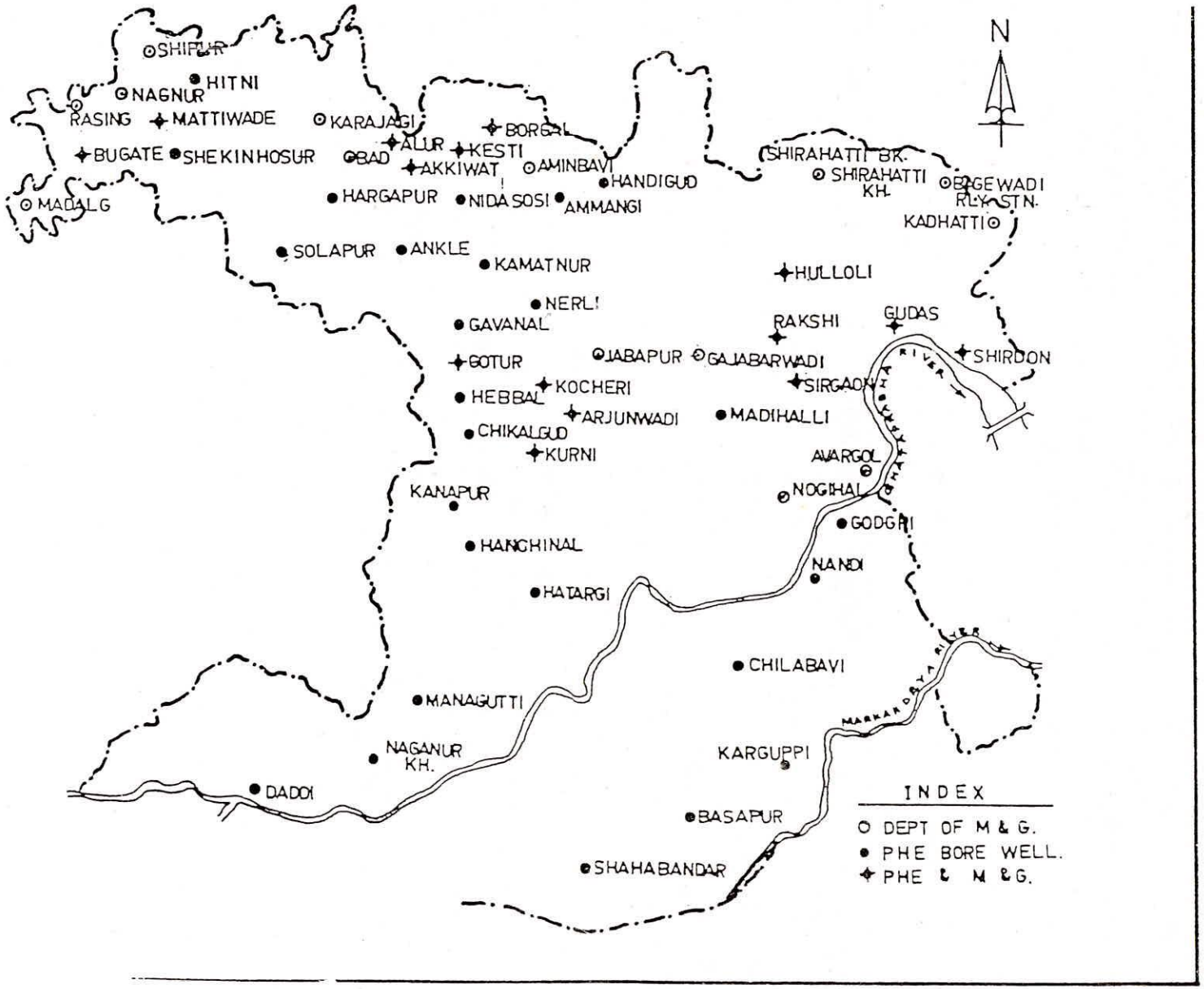

Fig. 7. Location of bore well extension data

Purandara et.al.(1992) and its later extension upto 1993, estimated the groundwater balance of the Ghataprabha basin with an integrated approach by dividing the whole basin area into 8 existing taluks. This estimates are enumerated yearwise in table 4. alongwith the average annual rainfall of each taluk. For simplicity in comparison these are abstracted in Table 5. On the basis of the estimates and some local informations it was decided to carry out 9 pumping tests in the location called Gajabarwadi just adjacent to Hukkeri town in an area of 4 to 5 sq. km (Fig.4). Monthly water levels in these wells are monitored for the season 1994-95 and accordingly groundwater balance for that small area has been estimated so as to have an rough estimate of the seriousness of the problem in that location.

Table.4 Talukwise Yearly Groundwater Recharge in MCM and Rainfall in m.

Year	Chickodi	Gokak	Hukkeri	Raibag	Jamakhandi	Mudhol	Bilgi	Bagalkot
1986 GWR	97.96	42.22	31.25	11.05	49.89	29.8	18.06	23.44
Rf (m)	0.57	0.42	0.58	0.16	0.728	0.50	0.43	0.44
1987 GWR	38.19	61.76	34.15	30.94	77.56	37.02	45.33	54.87
Rf(m)	0.519	0.414	0.384	0.446	0.634	0.674	0.673	0.711
1988 GWR	93.42	122.9	134.5	93.91	19.9	82.01	33.2	45.13
Rf(m)	0.636	0.594	0.630	0.758	0.597	0.591	0.407	0.453
1989 GWR	74.48	132.0	56.34	44.37	99.68	69.85	23.12	49.42
Rf (m)	0.576	0.458	0.685	0.415	0.607	0.586	0.492	0.606
1990 GWR	48.02	51.61	1.74	33.97	18.75	27.5	19.6	17.99
Rf (m)	0.479	0.572	0.416	0.339	0.227	0.227	0.138	0.266
1991 GWR	134.6	26.95	67.88	68.65	51.23	27.93	15.3	47.58
Rf (m)	1.054	0.528	0.851	0.650	0.482	0.157	0.695	0.525
1992 GWR	81.25	86.03	22.98	41.19	33.06	16.35	15.3	15.68
Rf (m)	0.717	0.977	0.361	0.543	0.300	0.193	0.159	0.157
1993 GWR	96.04	32.13	58.00	26.98	46.08	31.34	21.47	36.54
Rf (m)	0.977	0.404	0.702	0.486	0.552	0.403	0.487	0.584

Table.5 Comparative Hydrological condition in Hukkeri Taluk.

	Ghataprabha Basin Average in m.			Hukkeri Taluk Average in m.		
Year	Rainfall	GWR	Ratio	Rainfall	GWR	Ratio
1986	0.480	0.035	7.29 %	0.580	0.032	5.52 %
1987	0.555	0.044	7.92 %	0.384	0.034	8.85 %
1988	0.580	0.082	14.13 %	0.630	0.136	21.59 %
1989	0.555	0.063	11.35 %	0.685	0.057	8.32 %
1990	0.330	0.026	7.88 %	0.416	0.011	2.64 %
1991	0.430	0.051	11.86 %	0.650	0.069	10.61 %
1992	0.620	0.036	5.81 %	0.361	0.023	6.37 %
1993	0.570	0.040	7.02 %	0.584	0.059	10.10 %

6.0 PUMPING AND RECOVERY TESTS

Nine numbers of pumping and recovery test were carried out in the location called Gajbarwadi very adjacent to Hukkeri Town. All these wells were private wells having pump set with a capacity of 3 hp to 5 hp. Kumaraswamy's method has been opted for the analysis of the pump test as these wells are drawing water on unconfined to semi-confined aquifers of the hard rock region. Drawdown curves shown in Fig. 7 explains that the drawdown were not uniform so as to use the later method. However Slichter method has been utilized to compare the storage capacities in recovery performance after estimating additional parameter, Q*t/A during pumping as identical.

6.1 Kumaraswamy's method :

Mathematical equations defining inflow of groundwater to the wells and behaviour during recuperation were developed (Fig. 8) with following basic assumptions :-

1. Flow into the well is only through very minute fracture conduits of fissure planes opening through the inner surface of the well. These planes of very small cross-section are stacked horizontally over one another and no cross flow is assumed in between these fissure planes.

2. Water travels from an outer feed surface limited to short extents from the well.

3. The flow in the plane is laminar considering the Reynold's numbers and temperatures involved.

4. The operative depth of well is reckoned below the static water-level and no flow occurs above static water level. No flow is assumed to enter through the bottom of the well.

5. The static water level outside feed surface is not lowered during the period of test on account of the insignificant pumpages.

The following well parameters were recommended to be determined during pumping test on open wells in hard rock areas (Fig. 6)

1. Hard Rock well permeability "w" expressed in M/hr
2. Maximum inflow capacity of well "Q max " (Cubic M/hr)
3. Time taken for 99 % recuperation tR (Max).

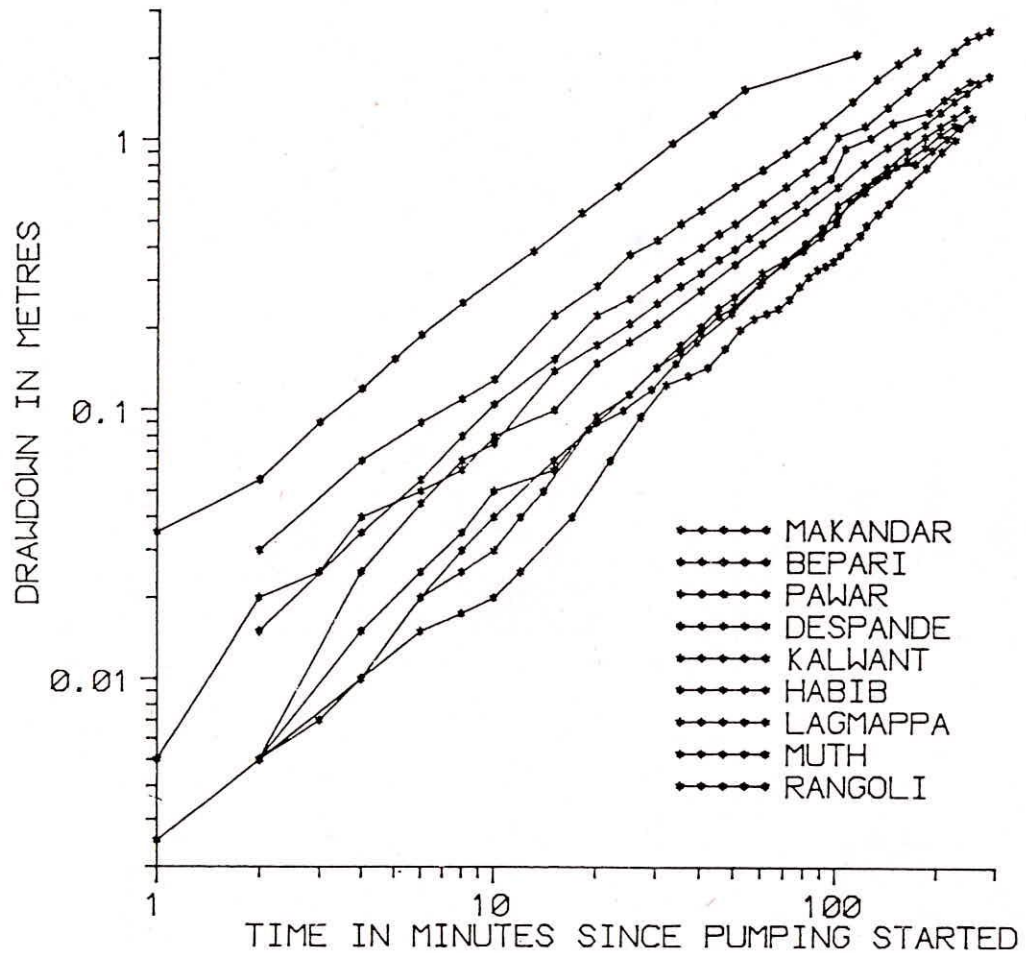

FIG. 3.. TIME DRAWDOWN PLOT OF TESTED WELLS
(PAPADAPULOS-COOPER METHOD)

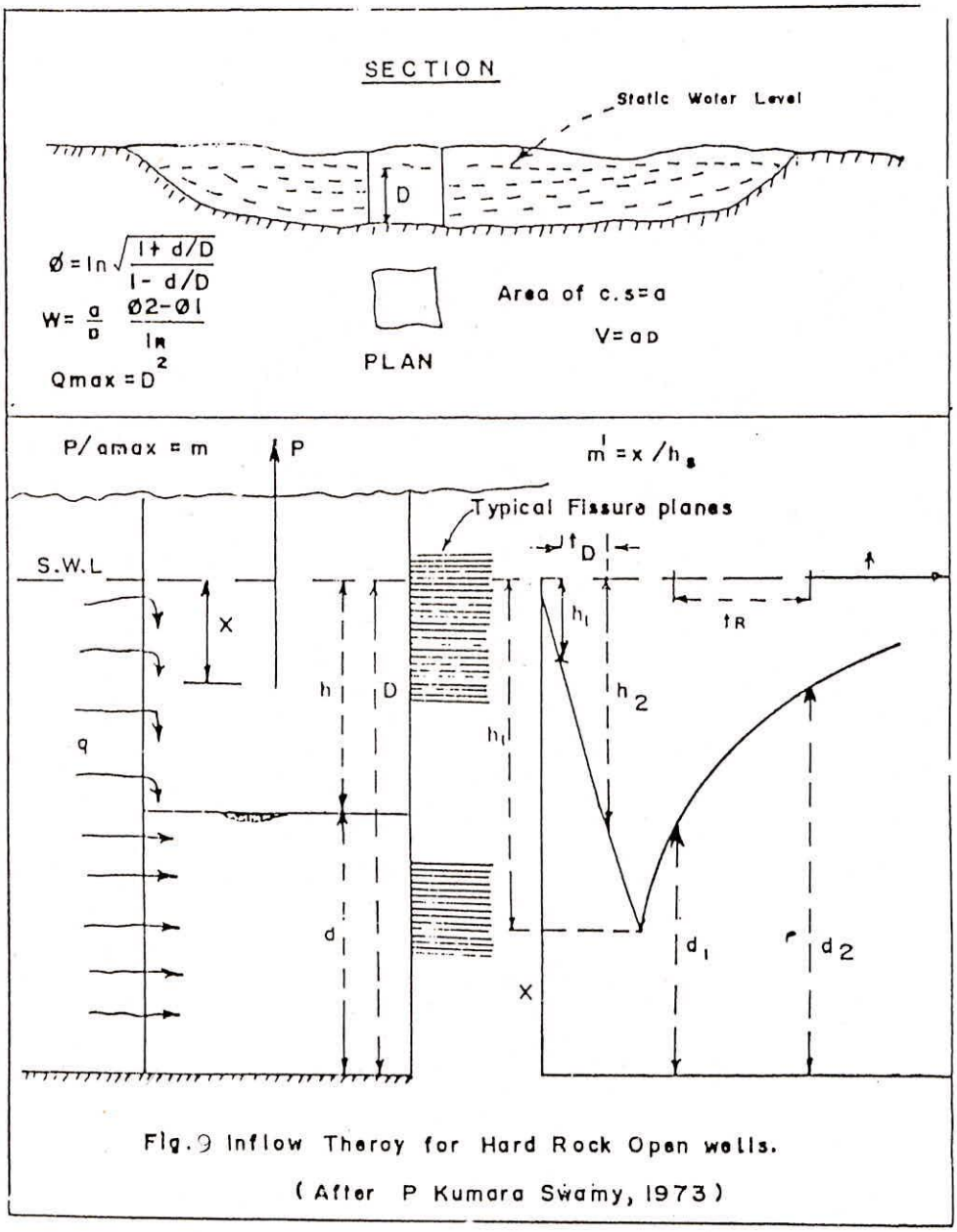

Fig. 9 Inflow Theroy for Hard Rock Open wells.

(After P Kumara Swamy, 1973)

Procedure Of Pump Test

1. Measure area of cross section of well "a" and the static water column "D". Pump out such that the water column reduces to about 0.3 D or say d1

2. Observe the time taken (tR) for water in the well to recuperate from d1 to d2 (width of water column after tR)

3. Calculate the hard rock permeability "w" by applying the following equation

$$w = (a / d) * [\ln \sqrt{(1 + d2 / D) / (1 - d2 / D)} - \ln \sqrt{(1 + d1 / D) / (1 - d1 / D)}] / tR$$

4. The maximum inflow capacity of the well can be calculated by applying the equation

$$Qmax = w*D$$

5. The time taken for 99 percent recuperation of well is given by equation.

$$tR\ (Max) = 2645*a*D / Q\ Max$$

The basic assumptions to develop the inflow theory may not be true for all the hard rock areas because during pumping test cone of depression is formed and the static water level outside feed surface is lowered during the period of test. Also,it is difficult to imagine horizontal flow from minute fractures without any cross flow. In the present case all these assumptions are found out to be very nearly valid to the field conditions. However, Time- Drawdown data plot of all the wells are depicted in figure 7 as used in Pappadapulos- Cooper method and data plot of log s1/s2 of tested wells are plotted in figure 9 to have an idea of specific capacities.

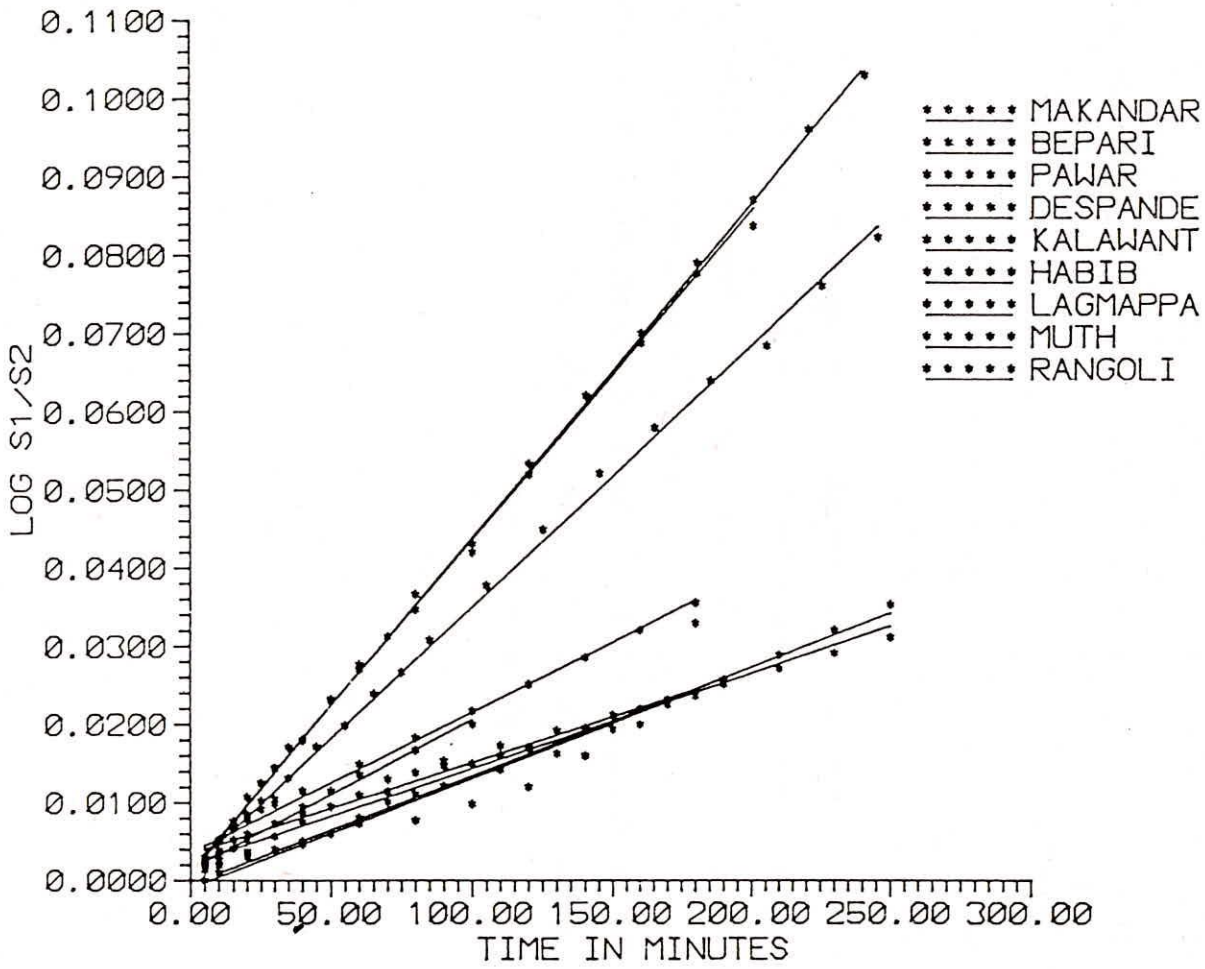

FIG 10: DATA PLOT OF LOG S1/S2 OF TESTED WELLS IN HUKKERI TALUK.

6.2 Well description & Pumping test Result :

6.2.1 Well no 1 :

Owner of the well is Mr. I.G. Makandar. This is located in an agriculture land. Aquifer material is composed of Deccan traps. Rock show varying stages of decomposition. Structurally the region has undergone moderate weathering. Spheroidal weathering is commonly seen on the surface. There are about 7-8 vertical joints with a spacing of 2-2.5m . Laminar flow of basalt is common here. Each layer is 3 to 4 ft in thickness. In certain layers small vertical and horizontal fractures are seen. However, it seems that these fractures does not play any significant role in transmitting water. Water is mainly sprouted through the joints. Contribution from the bottom is very less.

Well is somewhat square in shape with an area of about 64 sq.m. The water level fluctuates between 3.2m and 5.2m during the period from September to January.Qualitatively water is good and can be used for both irrigation and drinking.Ph of water is 7.8 and the temperature is 22.3 C. Well water is mainly used for agriculture purpose. Generally, water is pumped from the well thrice in a week and for about 3-4 hrs on each day. Major crops grown are ground nut and sugarcane. As per the information of the owner water is sufficient for the agriculture of 3-4 acres of land through out the year.

Aquifer Parameters determined through Pump test.

1. Total depth of the well.....= 13.33m
2. Static water level.....= 5.15mbgl
3. Area of the well (a).....= 64 sq.m
4. Static water column (D).....= 8.18m
5. Drawdown created (s1).....= 1.76m (in 280 minutes)
6. Maximum recovery (s2).....= 0.13m (in 180 minutes)
7. Water column after pumping(d1).....= 6.42m
8. Length of water column after recuperation(d2)..= 6.55m
9. Permeability(w).....= 0.13 m/hr
10. Qmax (wD).....= 8.698 cu. m /hr
11. tR max.....= 159 hrs
12. Pumping factor Q*t/A..... = 0.134
13. Specific capacity as per Slichter's method.....= 0.0174 cu. m/min/m

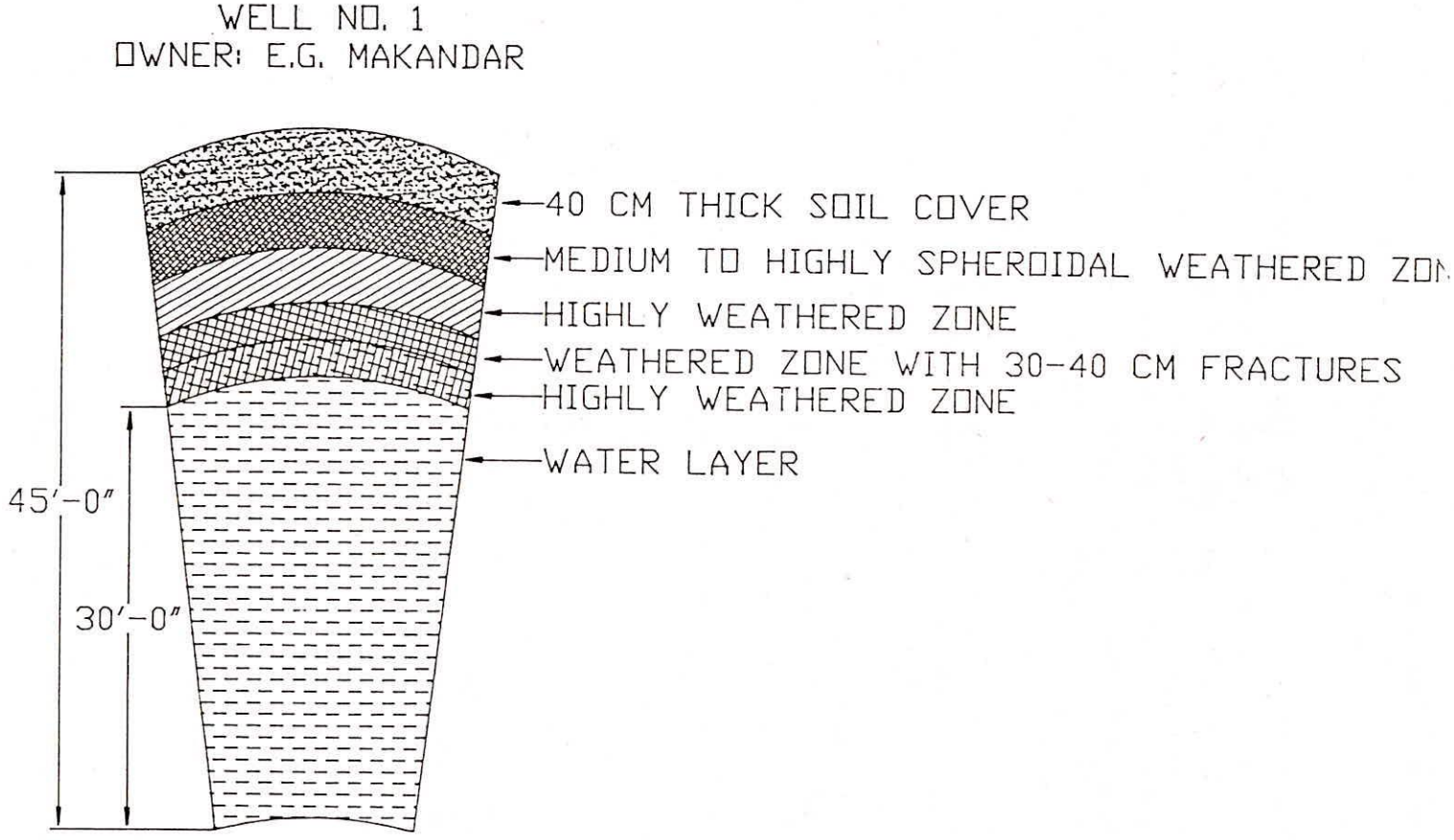

Fig. 11a. Well litholog of Well No. 1

6.2.2 Well No. 2 :

This well belongs to Mr. Pir Saheb Bepari. Auifer material is Massive basalts at the top underlined by a layer of basalts with moderate to weathering. Rock is medium hard and shows increased decomposition towards the bottom end. Top layers show intensive spheroidal weathering. Structurally it may be rated as Massive to Moderate zone. Joint and fracture condition is fairly good. Vertical joints are very minimum. Minor fractures are present on the walls of the well. It is said that the water is mainly supplied from the bottom layers than from the sides.

Well is in shape with an area of 134.55 sq. m. Average water level fluctuates between 4 to 5 m during September 1995. Qualitatively water is potable and also good for irrigation. pH of the water is 7.5 - 8 and the temperature is 22 C. Conductivity is about 0.8. Water is mainly used for agriculture. Water is pumped for 2 - 3 days in a week for about 3 - 4 hours on each day. Well is fitted with a motor of 3 hp which discharges water at a rate of 0.04865 cu. m / min. From this well 4 acres of land is irrigated. The crops grown are sugar cane, groundnut, Mirchi, Wheat,. Well dug in the year 1976.

1. Total depth of the well.....= 13.3 m
2. Static water level.....= 5.07 mbgl
3. Area of the well(a)..... = 13 m X 10.35 m
4. Static water column(D)..... = 8.26 m
5. Drawdown(s1).....= 1.02 m (in 222 minutes)
6. Maximum recovery(s2).....= 0.050 m (in 180 minutes)
7. Water column after pumping(d1).....= 7.245 m
8. Length of water column after recuperation(d2).... = 7.295 m
9. Permeability(w).....= 0.146 m/hr
10. Qmax (wD).....= 9.96 cu. m / hour
11. tR max.....= 295 hrs
12. Pumping factor Q*t/A.....= 0.08
13. Specific capacity as per Slichter's method.....= 0.0124 cu. m/min/m

WELL NO. 2

OWNER.: P.S.Bepari

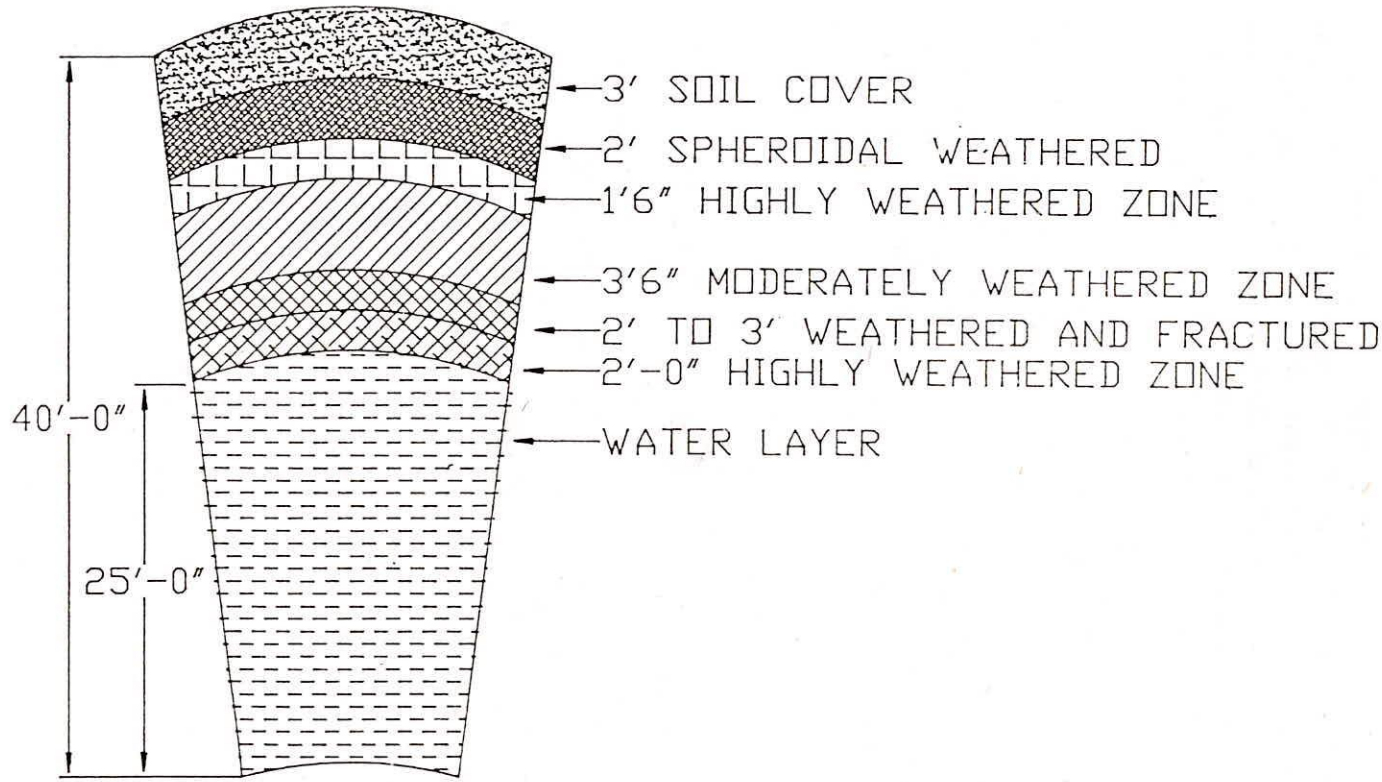

Fig. 11b : Well litholog of Well No. 2

6.2.3 Well No. 3 :

Mr. Jyotiba Gundu Pawar is the owner of this well. Aquifer mainly consists of basaltic rocks. Rocks show moderate to intense weathering in some zones. Rock shows medium hardness with rough outer surface. Structurally it may be included under slightly faulted class. Number of joints and fractures are good. Both vertical and horizontal planes exhibits joints and fractures. It is clearly observed that water is seeped through the joints and fractures and it is also said that the contribution from the bottom is negligible when compared to the sides.

Well is square in shape with an area of 49 sq. m. Average water level, fluctuates between 2.5 to 3.5 m during October 1994 to January 1995. Qualitatively water is good for both drinking and agriculture purposes. Water is pumped daily for 2 - 7 hours. Water is used mainly for agriculture of 5.5 acres land. Major crops grown are Sugar case (3 acres) in the remaining area jowar, mirchi, cotton, etc. are grown. Well is fitted with 3 hp motor and the average discharge is 0.053 cu. m /min. Well was dug in the year 1985.

1. Total depth of the well.....= 16 m
2. Static water level.....= 7.25 mbgl
3. Area of the well (a) .....= 49 sq.m
4. Static water column(D).....= 8.75m
5. Drawdown(s1) ..... = 1.235m (in 249 minutes)
6. Maximum Recovery(s2).....= 0.255m (in 240 minutes)
7. Length of water column after pumping(d1)..... = 7.52m
8. Length of water column after recuperation(d2).....= 7.775m
9. Permeability (w).....= 0.175 m/hr
10. Qmax (wD) .....= 13.42 sq.m/hr
11. tR max.....= 84.5 hrs
12. Pumping factor Q*t/A .....= 0.27
13. Specific capacity as per Slichter's method.....= 0.043 cu. m/min/m

6.2.4 Well No.4 :

Owner of the well is Mr. N. V. Deshpande. Aquifer is composed of Basalts (Deccan traps). Structurally the region has undergone moderate to intense weathering. Soil thickness is comparatively more (1 1/2 - 2 m). Vertical and horizontal joints are seen in the adjacent aquifer. Transmission of water is mainly through laterals than from the bottom.

Well is rectangular in shape with an area of 77.4 sq. m. Average water level fluctuation is from 4.25 to 6.3 m during September 94. to January 1995. Water is quite good and usable for both irrigation and domestic purposes. Ph is 7 and the temperature is 24 C. Water is mainly used for agriculture. Pumping is done 3 - 4 times in a week with 6-8 hours duration on each day. This water is used for agriculture of 2.5 acres of land. Major crops grown are sugar cane, hybrid maize, Banana plantation, Beter Plants. A motor of 5 hp capacity is fitted. It discharges 0.0988 cu. m / min of water. This well is 60 - 70 years old. During 1973 acute drought was there and well was dry in that year. Well was deepened in the year 1987 and it resulted in higher yield. Two borewells have come up in the adjacent areas. One in the same location and excess water from the bore is released to the open well.

1. Total depth of the well.....= 15m
2. Static water level.....= 4.26 mbgl
3. Area of the well(a) ..... = 77.4 sq.m
4. Static water column(D) .....= 10.74m
5. Drawdown(s1) .....= 1.68m (in 245 minutes)
6. Recovery(s2) .....= 0.29m (in 245 minutes)
7. Length of water column after pumping(d1).....= 9.
8. Length of water column after recovery(d2).....= 9.35m
9. Permeability w.....= 0.148 m/hr
10. Qmax (wD) .....= 17.07 cu.m/hr
11. tR max .....= 128.8 hrs
12. Pumping factor Q*t/A.....= 0.31
13. Specific capacity as per Slichter's method.....= 0.059 cu. m/min/m

6.2.5 Well No. 5 :

Owner of the well is Mr. Babu Kalawant. This is a good aquifer composed trap rocks located in an agriculture land. Soil cover is comparatively good and below the soil layer a thick medium to hard rock mass present. Structurally area has undergone a wide range of weathering which is exhibited at different layers at depth. Vertical and horizontal are good in number. Water is transmitted from all directions of the well.

Well is somewhat square in shape with an area of 29.16 sq. m. Average water level fluctuates between 2.17 m to 4 m during September 1994 to January 1995. Water is potable and also good for irrigation is 22 C. Water is used for agriculture. Pumping is done thrice in a week with 2 - 3 hours duration. Total command under this well is 2 1/2 acre. Sugar cane (1 1/2 acre), Jowar, Mirchi, wheat and onion are the major crops. 3 hp motor is used with a discharge of 0.0784 cu. m / min. Well was dug in the year 1978. During 1986-87 drought well was almost dried and water was used for only drinking purpose.

1. Total depth of the well.....= 11.66m
2. Static water level.....= 2.76mbgl
3. Area of the well(a) .....= 29.16sq.m
4. Static water column(D).....= 8.90 m
5. Drawdown(s1). .....= 2.595m (in 280 minutes)
6. Recovery(s2) .....= 0.455m (in 200 minutes)
7. Length of water column after pumping(d1).....= 6.905m
8. Length of water column after recovery(d2).....= 7.36m
9. Permeability(w)..... = 0.141 m/hr
10. Maximum inflow capacity of the well Qmax(wD) ..... = 11.1555 cu.m/hr
11. Time taken for 99% recuperation (tR max) .....= 61.5 hrs
12. Pumping factor Q*t/A..... ...= 0.75
13. Specific capacity as per Slichter's method.....= 0.078 cu. m/min/m

6.2.6 Well No. 6 :

Owner of the well is Mr. Jamalshat Guru Nadshah. This is located in a valley which is about 3 - 4 m form the ground level. Deccan traps acts as an aquifer in this zone. Rock is massive in nature and comparatively hard. Highly disintegrated yellow to dark grayish soil are seen as thin layers between the hard rock masses. Lateral and bottom transmission of water is reported from this well.

Well is circular in shape with an area of about 72.35 sq. m. Water level in the well fluctuates between 2.5 m and 3.5 m during October '94 to January 1995 Command area of this well is only 3 acres. Water is quite good for both irrigation and domestic purpose. Pumping is done weekly thrice for about 7 - 8 hours on each day. Sugar cane and wheat are the major crops. 3 hp motor is fitted which discharges at a rate of 0.046 cu. m /min.

1. Total depth of the well .....= 13.33m
2. Static water level .....= 3.25mbgl
3. Area of the well(a) .....= 72.38 sq.m
4. Static water columnD..... = 10.08m
5. Drawdown(s1) .....= 1.335m (in 240 minutes)
6. Recovery(s2) .....= 0.105m (in 180 minutes)
7. Length of water column after pumping(d1)..... = 8.745m
8. Length of water column after recovery(d2).....= 8.85m
9. Permeability w .....= 0.1045m/hr
10. Maximum inflow capacity of the well Qmax (wD) .....= 10.62 cu.m/hr
11. Time taken for 99% recuperation (tR max).....= 181.7 hrs
12. Pumping factor Q*t/A.....= 0.155
13. Specific capacity as per Slichter's method.....= 0.035 cu. m/min/m

6.2.7 Well No. 7 :

Owner of the well is Mr. Siddalingappa lagamappa. Well is located on an elevated horizon which show dip on all directions. Source rock is Deccan trap which are fine grained in nature. Structurally rock is massive in nature in the top layers however show moderate weathering zones in the deeper layers. Horizontal joints are found at a depth of about 6 - 7 m below ground level with a spacing of 1 1/2 - 2 m. These joints are found only on the west and southern sides of the well.

Well is rectangular in shape with an area of 51.8 sq. m. The water level fluctuates between 7 m and 12.9 m during September 1994 to January 1995. Water is qualitatively good for irrigation and domestic purposes. Ph of the water is 6.5. Temperature of water 22.2 C Water is used for agriculture purpose. Command are of this well is 4 acres. Generally pumping is done thrice in a week with duration 3 - 4 hours on each day. Major crops grown are sugarcane (2 acres) Groundnut, Brinjal, Wheat and Cotton. A 3 hp motor is fitted and discharges 0.0345 cu. m / min of water. Well was constructed in the year 1989-90. Well used to be dry in each year. Presently deepening of the well is under progress.

1. Total depth of the well.....= 16m
2. Static water level.....= 12.9 mbgl
3. Area of the well(a) .....= 51.8 sq.m
4. Static water columnD.....= 3.10m
5. Drawdown(s1) .....= 2.175m (in 170 minutes)
6. Recovery(s2) .....= 0.17m (in 250 minutes)
7. Length of water column after pumping(d1) .....= 0.925m
8. Length of water column after recovery(d2).....= 1.095m
9. Permeability(w)..... = 0.247 m/hr
10. Maximum inflow capacity of the well Qmax(wD) .....= 2.3778 cu.m/hr
11. Time taken for 99% recuperation (tR max) .....= 178.6 hrs
12. Pumping factor Q*t/A.....= 0.135
13. Specific capacity as per Slichter's method.....= 0.0159 cu. m/min/m

6.2.8 Well No. 8 :

This is a well used for social purpose owned by a Siddrudh muth. This is comparatively smaller in diameter. well is located in a valley. Aquifer is composed of traps. Rock is medium to decomposed in hardness. Structurally it is moderately weathered without any major faults, joints and folds. There are few joints and fractures which aid in transmitting water from lateral sides.

Well is circular in shape with an area of 46.24 sq. m water level fluctuates 2 to 3 m during November 1994 to January 1995. Qualitatively water is potable. Ph of the water is 7.5 and temperature is 23 C . Command area of the well is 1 - 2 acres of land. Usually Groundnut, wheat and mirchi are grown here. Well is fitted with a 3 hp motor and discharges water at a rate of 0.0165 cu. m / min

1. Total depth of the well.....= 7.2 m
2. Static water level .....= 2.675 mbgl
3. Area of the well(a) .....= 36.3168 sq.m
4. Static water column(D).....= 4.525m
5. Drawdown(s1) ..... = 1.16m (in 220 minutes)
6. Recovery(s2) .....= 0.08m (in 250 minutes)
7. Length of water column after pumping(d1).....= 3.37m
8. Length of water column after recovery(d2) .....= 3.45m
9. Permeability w .....= 0.08m/hr
10. Maximum inflow capacity of the well Qmax(wD) .....= 1.615 cu.m/hr
11. Time taken for 99% recuperation (tR max) .....= 269 hrs
12. Pumping factor Q*t/A .....= 0.076
13. Specific capacity as per Slichter's method.....= 0.014 cu. m/min/m

6.2.9 Well No. 9 :

Well Description: This well belongs to Mr. Ashok Rangoli Well is located in a valley which is about 3-4m below ground level. It shows dip towards South and West directions. Geologically, the region is covered by basalt with a thin cover of lateritic soil. Below the thin layer of lateritic soil, massive basalts are seen followed by zones of spheroidal weathering intervened water boundary, the rocks show good number of fractures and joints. But number of vertical joints are very few. However, this well is presently under construction.

Observations in the field showed that the source of water is mainly from the dipping directions. The water available zone is marked between 10.8 m /2.8 m (10.8m along the valley and 2.8 m across the valley). The maximum depth of the well can go up to 30 ft. Diameter can be fixed as 10.8 m (along the valley) and 2.8 m (across the valley). A 3 hp motor is fitted to the well which discharges water at a rate of 0.031 cu.m/min.

1. Total depth of the well.....= 2.35 m
2. Static water level.....= 0.24mbgl
3. Area of the well (a) .....= 30.24 sq.m
4. Static water column D.....= 2.11m
5. Drawdown (s1) .....= 2.10m (in 70 minutes)
6. Recovery (s2) .....= 0.085m (in 100 minutes)
7. Length of water column after pumping d1.....= 0.01m
8. Length of water column after recovery d2.....= 0.095m
9. Permeability w .....= 0.346 m/hr
10. Maximum inflow capacity of the well Qmax (wD) ..... = 1.543 Cu.m/hr
11. Time taken for 99% recuperation (tR max) .....= 109 hrs
12. Pumping factor Q*t/A .....= 0.071
13. Specific capacity as per Slichter's method.....= 0.0147 cu. m/min/m

7.0 RESULTS AND DISCUSSIONS

It is believed that rainfall is the major source of ground water recharge . After analysing, it has been found that in the last 11 years (year 1983 to 1993), there is not much variation in the annual figures of either present rainfall in the individual raingauge stations or in yearly average over the entire region, except in Sarapur. In most of the year there is not much variation in the station values of coefficient of variation. It is ranging between 0.17 to 0.42. In fact rainfall at Daddi which comes inside Hidkal dam catchment provides much of the variation by receiving appreciable amount of rainfall as compared to annual average in most of the locations. Sarapur has experienced much more variation in rainfall and mostly below the average annual. Therefore , rainfall is more in the southern half of the region upto Hukkeri. Where as the Northern portion of the region does get less amount of rainfall.

After adjusting the monthly values of evaporation of the respective years and/or average values as per the availability, it is evident that surplus water for ground water recharge is available mostly in the month of June to August in the location having good rainfall. Drainage pattern shows that the study area being an elevated one, overland flow may be more and with high velocity so as to give very little scope to this water to enter the soil profile with an average moderate infiltration rate. Also, as the soil cover is much less than 6m, appreciable quantity of this penetrating water may be lost through evapotranspiration (De vries,1984). With all the nallas and streams of the region having intermittent flow. active recharge through rainfall may not be that good specially in the northern part of the region.

Monthly water levels for last 8 year (Year 1986 to 1993) for open wells at Hukkeri and Yadgud reveals the fact that water level declines for the initial 5 months that is January to May and then it is being replenished till Sept - Oct. After October again water level start declining. Water level fluctuation has also been increased considerably during last 18 years when State Department of Mines and Geology first carried out the survey in 1975, which shows the increase in groundwater exploitation through open wells in shallow aquifers and through bore wells from deeper layers. The fact is being supported by the monthly water level of some of the selected bore wells of the region. In so many places it has been found almost dry after April and got collapsed, thereafter, due to lack of good rainfall. Again situation look better in the southern part as compared to Northern area as former may be gifted away some share of ground water recharge from, the main tributaries of Ghatprabha river namely; Hiranyakeshi and Markendyahalla, and the submerged area of Hidkal dam reservoir. Overall Landuse pattern has not undergone any appreciable changes but sugarcane production varied and thereby affecting the well storages specially near Sankeshwar due to upcoming sugar industries, but subsequent rainfall recharges and other interbasin recharge transfer replenishes it to possible extent.

As per the information of failed open wells they are found segregated in the Northwest region and around Hukkeri Town. As per the pump test results of State Department of Mines and Geology in year 1993-94 failed wells are again in the same region having a depth range from 9 m to 14.7 m and area of cross section ranging from 80.75 sq.m to 380.13 sq.m . They are mostly in trap formation and having influenced by one or two wells in the nearer vicinity.

It has already been concluded by the earlier studies that the inflow in to the well is from the fracture and joints of the rock mass. Therefore it is felt that neither the specific capacities through Slichter's method with various other modification nor Transmissivity and Storativity values calculated by Papadopulos and Cooper's method would able to project the actual ground water flow conditions to the open wells of the region. Rock mass permeability may be more indicative of the ground water yield to the wells. Therefore the pump test results were analysed through Kumarswamy's method. However time drawdown curve as required by Papadopulos and Cooper's method has been prepared as a point of reference to the state of drawdown. Moreover, specific capacities have also been estimated through Slichter's method as the drawdown factors are found to be similar to agreeable extent.

All the pump tests were carried out in Gajbarwadi, a small region adjacent to Hukkeri town where cases of failed wells have been found frequently. These wells are ranging from 29.16 SQ.M. to 134.55 SQ.M. in terms of area and from 2.35 M. to 16.0 M. in terms of depth. All the wells are rectangular in shape except well no 6 and 8 and exist in trap formation. Sample well lithology is presented in Fig 10 a&b for well no 1&2. Lithology for other tested wells are almost identical. Rockmass permeability value ranges between .08 m/hr. to .346 m/hr. Maximum inflow capacity of the wells comes out to be in between 1.543 cu.m/hr and 13.42 cu.m/hr. Estimated maximum time taken for 99 % of recuperation varies from 61.5 hr. to 295.4 hr for individual wells. Permeability values are less as compared to the values estimated by CGWB in 1980 in terms of transmissivity therein. Maximum inflow capacities are also less as compared to the work of State Dept. of Mines and Geology in year 1970 and CGWB in year 1980 ofcourse then the method of analysis was different. Time for the 99% recuperation so estimated were confirmed with the owners personal judgements and found quite authentic.

To establish the relation of depth and cross-sectional area of the well with all basic parameters so estimated through pump test data these were best fitted accordingly and only permeability is found to have relation with depth (figure 12) that is with increasing well depth, rock permeabilities are seem to have decreasing trend. Moreover, maximum time of 99% recuperation has better fitness with cross-sectional area as shown in figure 11.These two curves may be used as a reference for deciding depth and cross sectional area of a proposed well in the region under or very adjacent to the test plot after giving full weightage to structural geology of the location.

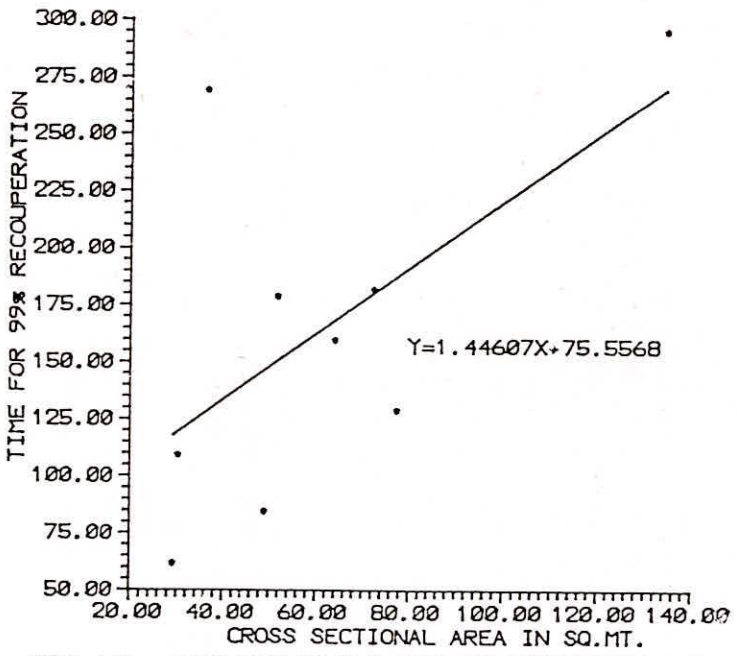

FIG. 12. BEST FIT OF C.S.AREA VS TIME TAKEN FOR 99% RECOUPERATION

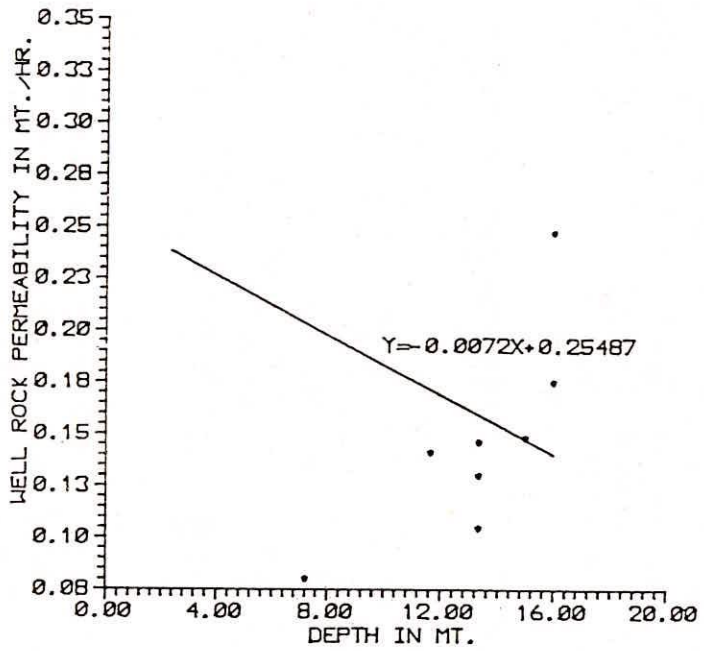

FIG 13 BEST FIT OF WELL DEPTH VS ROCK PERMEABILITY

If we look at the annual ground water balance of the Hukkeri taluk for last 8 years, it does not look alarming as on average 10% of the rainfall is available for groundwater recharge. It's comparison either with entire Ghataprabha basin or other individual taluks seems more or less same. Only matter of concern is the increase in the groundwater exploitation as compared to the less annual average rainfall and tapping of overland and subsurface water interacting with other basins and rivers. Such conditions give rise to the urgent need for artificial recharge facilities. Again the most effected area being the Northwest region and the area around Hukkeri town, possible scopes for artificial recharge has been checked for that region only, where mostly failed wells are found.

Physically the region lies in head reach of the Ghataprabha basin having comparatively good rainfall recorded in Sankeshwar and Hukkeri. Most interesting matter is that, the failed wells are existing in the area surrounded by these two locations. To understand the groundwater flow condition, the pre and post monsoon water level for two specific years namely 1989 and 1990 are plotted and mostly then flow occurs from North-west to South-east in the Taluk with a gradient of 2.26m/km. This gradient is high and is justified with the fact that the percolation tanks constructed in the zone dries up quite quickly without much benefit to the groundwater levels of the nearby locations. Extensive Sinking of Lift Irrigation wells have added to the problem, and consequently dried up the existing nallas which were perennial in the past.

The area under concern has no beneficial influence of Hidkal dam constructed on Ghataprabha river. Chikkodi branch canal passing through the taluk is not benefiting the area either as the canal is contour canal and have command on the other side of the canal. Moreover the canal being the lined one there is hardly any possibility of aquifer - canal interaction and the groundwater may be interacting with the downstream river stretch of the Hidkal dam directly which lead to a very specific study of groundwater potential of the study area before and after the construction of Hidkal dam.

For artificial recharge contour canal alignment may be considered as the demarcating line. Soil thickness being small, evaporation loss from soil has to be minimized and more and more percolation tanks alongwith surface and subsurface checkdams on nallas has to be preferred mainly on Hiranyakeshi river and its other minor tributaries before leaving the taluk. Underground cutoff wall all along the canal alignment may be a fruitful remedial measure to tap the subsurface water partially or completely on the Hukkeri side rather than water logging the command on the other side of this contour canal. These are all long term strategies and may be required to go for economic assessment for viability before implementation. Therefore immediate need is to stress for safe yield estimation and groundwater exploitation be regularised according to that estimate. However a tentative plan for artificial recharge of the area is shown in fig. 16.

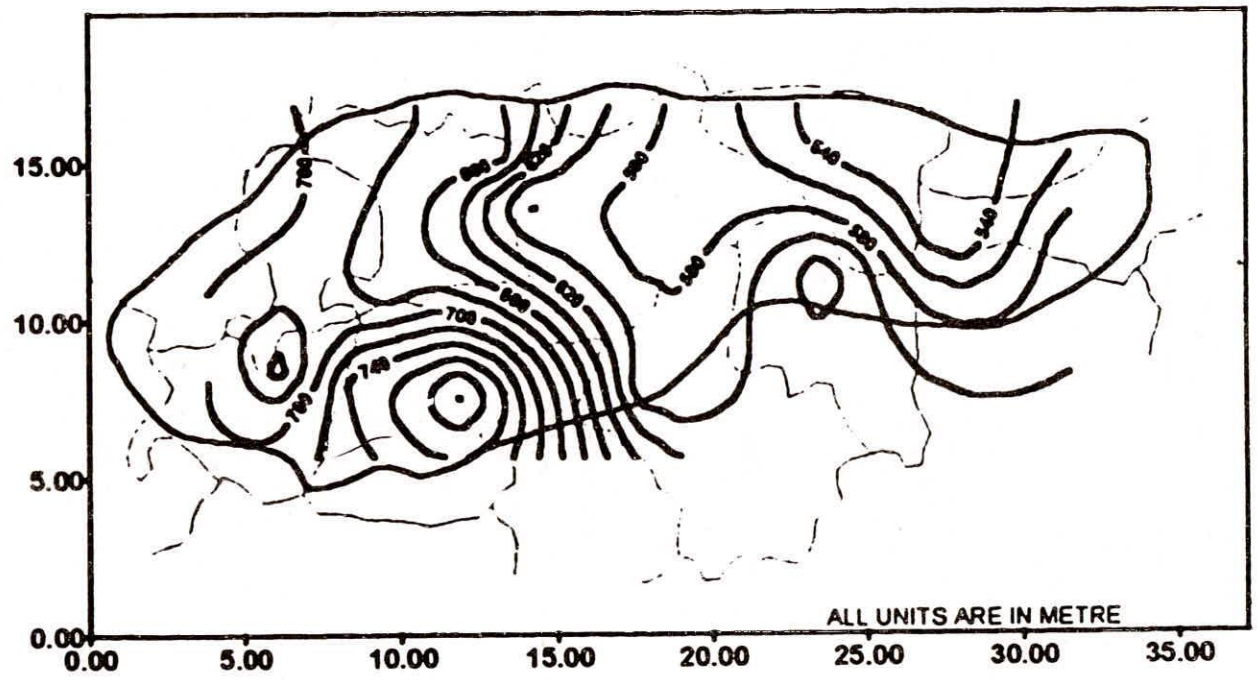

FIG. No.14a WATER LEVEL CONTOURS FOR PRE-MONSOON 1989.

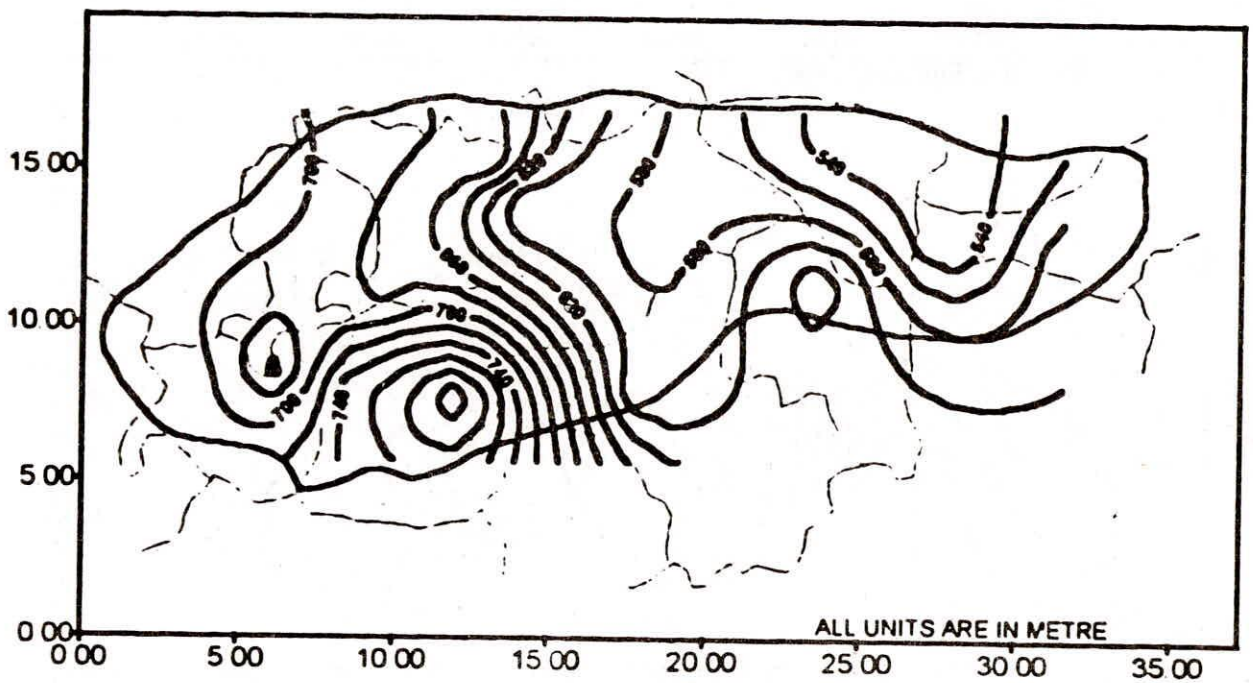

FIG. No. 14b WATER LEVEL CONTOURS FOR POST-MONSOON 1989.

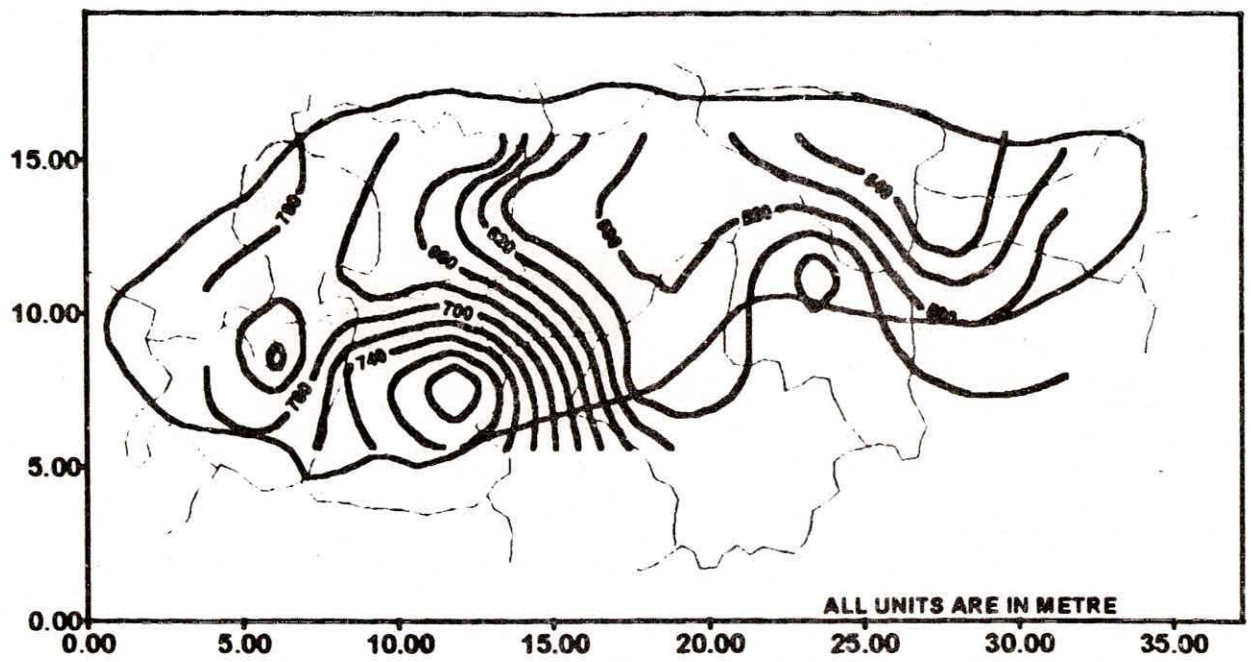

FIG. No. 15a. WATER LEVEL CONTOURS FOR PRE-MONSOON 1990.

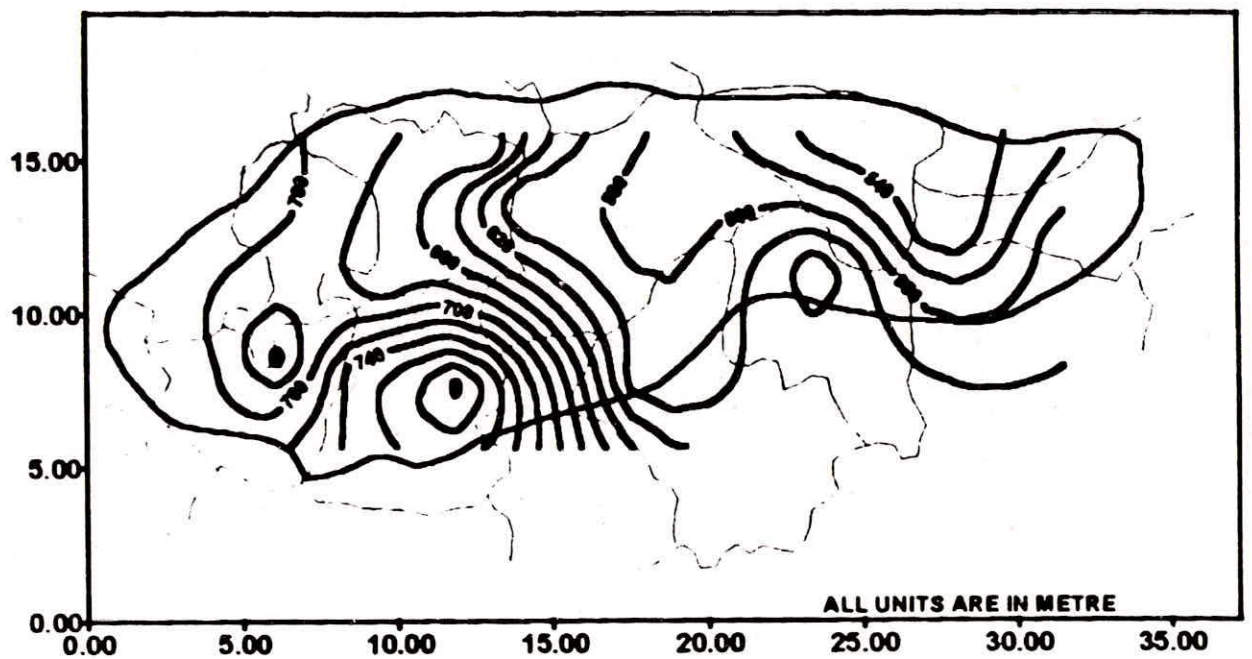

FIG. No. 15b. WATER LEVEL CONTOURS FOR POST-MONSOON 1990.

Regional groundwater modelling is recommended so as to identify the effect of fluctuating water level in the Ghataprabha river and that to specially in the downstream of the reservoir so as to formulate the reservoir operation strategies of Hidkal dam more beneficially.

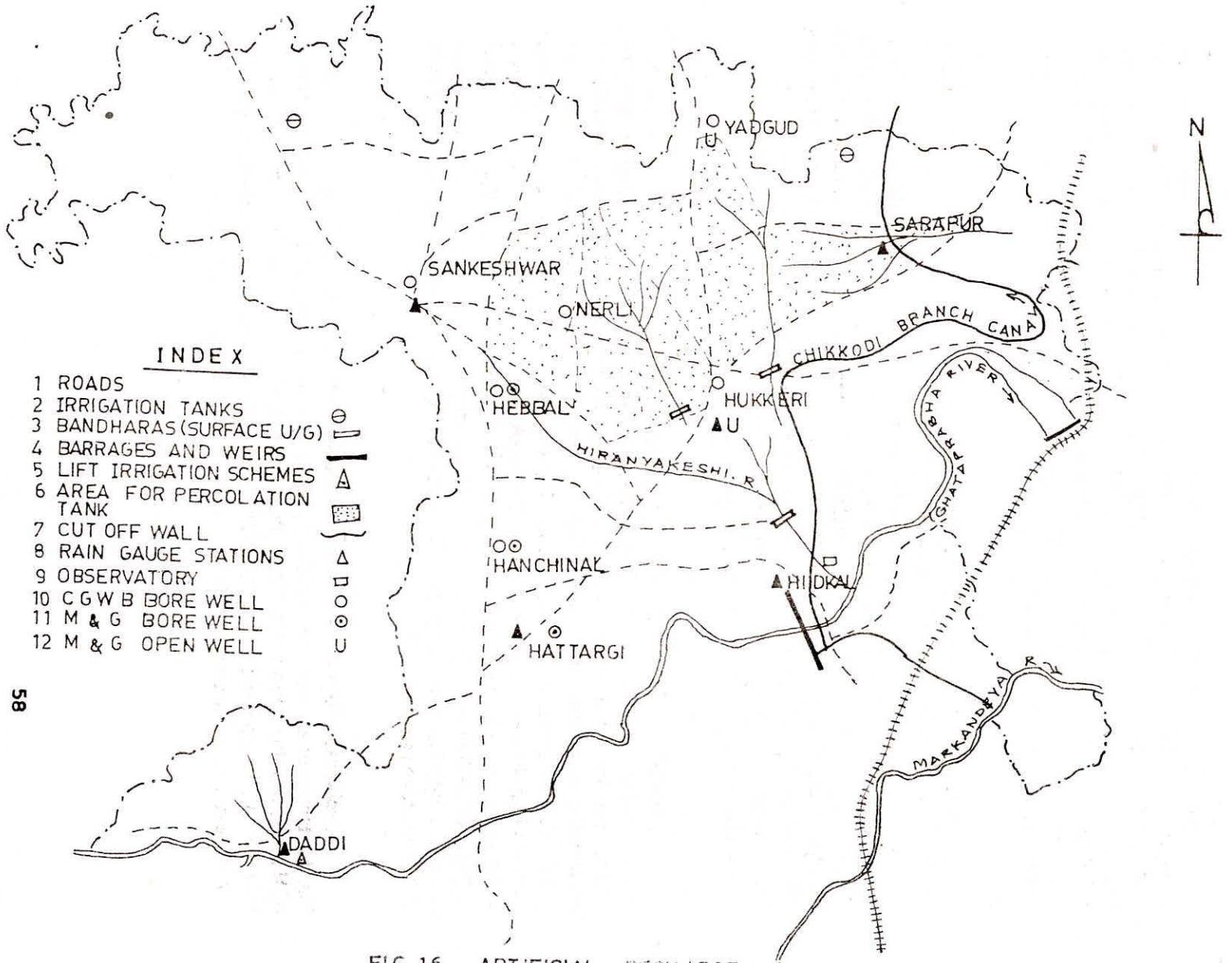

FIG. 16 ARTIFICIAL RECHARGE MEASURER

8.0 CONCLUSIONS

Study of open wells in Hukkeri taluk of Belgaum district in Karnataka state has been conducted. It is found that failure does occur mostly in the northern part of the region around Hukkeri town,where as southern part still looks in a better shape in terms of ground water recharge. Less rainfall, more evaporation intermittent stream flows due to extensive lift irrigation from wells and minimum soil cover may be some of the reasons for the failure of these wells. These wells are nearly fully penetrating and drawing water from unconfined aquifer through joints and fractures of trap, sandstone and quartzite formations.

Open wells of the region having large cross sectional area have failed even with shallow depths .Well rock permeability, maximum inflow rate and time taken for 99% recuperations are considered as more useful parameters as compared to Specific capacity,transmissivity and storativity and these are ranging from 0.08 to 0.346 m/hr,1.543 to 13.42 cum/hr and 61.5 to 295.4 hr.respectively. However for the matter of reference specific capacities estimated though Slichter's method ranges between 0.0124 to 0.078 cum/min/m. of drawdown.Best fit between well depth and permeability, and cross sectional area versus time taken for recuperation has been generated for future references. Both shows a natural trend although yet to be proved as unforced statistical analysis by incorporating more sample points.

Quantitative failure of any open well is the reciprocal of the disbalance between yield and exploitation of ground water. Hydrologically former is very much depending upon the structural geology of the location specially in hard rock areas as areal and temporal variations of geophysical parameters are frequent both in terms of quantity and direction. It can be concluded that groundwater exploitation be regularised as per the estimate of safe yield calculated on the basis of sensitive parameters. Apart from that some long term management strategies has to be initiated like percolation tanks at least one in each village and possible tapping of all tributaries with underground check dams. Cut-off wall at least upto soil and weathered layer has to be constructed all along the canal alignment. This necessitates more in the areas where canal is in filling.

A schematic diagram of artificial recharge measures are depicted in the map shown in Fig. 16. However all these decisions would be supported by regional mathematical modelling of the basin in due course. This being the first study, strategic formulation for the study of failure of open wells should cover detailed meteoric, surface and subsurface investigations. This would serve as a recommendation for the future studies in other locations also.

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APPENDIX - A Village wise existence of Wells

Sl. No.	Name of Village	Number of BoreWells	Number of Dug cum Bore Wells	Number of Dug Wells	Others	Total Wells	Area Irrigated
1	Arjunwad	1	--	50	-	51	24.77
2	Sankeshwar	2	--	134	--	136	48.20
3	Jabapur	1	--	50	--	51	64.04
4	Hukkeri	30	--	334	--	364	316.04
5	Hulloli	10	--	222	--	232	73.31
6	Kotabagi	3	--	163	--	166	407.34
7	Rakshi	8	--	54	--	62	136.04
8	Keshti	--	--	145	--	145	79.26
9	Alur K.M.	--	--	59	--	59	29.68
10	Akkiwata	--	--	41	--	41	18.50
11	Amminabhavi	--	--	79	--	79	38.02
12	Boragalla	2	--	128	--	130	88.12
13	Gotur	5	--	60	--	65	--
14	Kochari	3	--	73	--	76	79.30
15	Masarguppi	3	--	34	--	37	54.22
16	Bada	--	--	87	32	119	37.61
17	Karjaga	3	--	83	--	86	34.80
18	Shipura	1	--	13	--	14	23.67
19	Nagnur,KS	--	--	30	--	30	45.00
20	B.Alur	1	--	38	--	39	90.48
21	Rasinga	1	--	52	--	53	144.80
22	Hadalga	--	--	13	--	13	34.44
23	Mathwade	--	--	40	--	40	64.40

APPENDIX - A: Village wise existence of Wells

Sl. No.	Name of Village	Number of BoreWells	Number of Dug cum Bore Wells	Number of Dug Wells	Others	Total Wells	Area Irrigated
24	**Bharapur**	**1**	--	**30**	--	**31**	**29.63**
25	**Shiranahosur**	**1**	--	**22**	--	**23**	**28.41**
26	**Shirgaon**	**38**	--	**146**	**16**	**200**	**300.00**
27	**Gudara**	**21**	--	**187**	--	**208**	**464.00**
28	**Shirahati. BK**	**19**	--	**133**	--	**152**	**764.17**
29	**Shirahatti. DK**	**19**	--	**77**	--	**96**	**673.09**
30	**Kurni**	**42**	--	**158**	--	**200**	**328.09**
31	**Avargol**	--	--	**69**	--	**69**	**228.00**
32	**Neginhal**	**01**	--	**38**	--	**39**	**156.25**
33	**B.Bagewadi**	**12**	--	**145**	--	**157**	**593.16**

APPENDIX- **B**

PUMP TEST RESULTS OF FAILED WELLS IN HUKKERI TALUK CONDUCTED BY DEPTT.OF M&G.BELGUAM.

Owner	R.S.No	Distance from Neare-st well	Date of Observation	Total depth	Areal cross section (in sq.m)	Capacity of Motor	Water level	Depth of Water column	Core Materials
P.B.Ghilari	51/14 Sultanpur	-	29-01-94	10.5 m	Collapsed	-	-	-	-
Gadagi	-	600 m (two wells)	29-01-94	11 m	93.73				0 - 1.5 m weathered soil 1.5 - 11 m hard traps
N.M.Mugali	80/Bellad Bagewadi	350 feet	29-01-94	14.7 m	115	5 h.p	0.4 m	14.3 m	0 - 14.7 m weathered basalts
M.A.Patil	145/5 Yadgud		29-01-94	10 m	201.06	5 h.p.	1 m	9 m	0 - 0.5 m soil cover 0.5 - 10 m weathered rocks
D.R.D.Bagol	259/1 Hukkeri		29-01-94	12 m	93.12	5 h.p	0.65 m	11.35 m	0 - 1.5 soil 1.5 - 12 massive rocks
M.M.Thotagi	216/1 A Hukkeri		29-01-94	12 m	80.75				0 - 1.5 red soil 1.5 - 7.2 weathered rock 7.2 below jointed rocks
S.B.Saheb	138 Kochari	200 m	21-01-94	9 m	380.13	3 h.p	8.55 m	.45 m	0 - 8 m deccan bassalts below 8 massive rocks
D.S. Hatti	138 Kotabagi	350 feet	29-01-94	11.2 m	314.16	5 h.p.	11 m	0.2 m	0 - 11.2 m hard rock
B.Parshuram	505/1 Shirgao		29-01-94	11 m	85.5	5 h.p			0 - 6.5 Blacksoil,pebbles
M.R.Patil	98/2 Nagnur		17-01-94	13 m	314.16				0 - 1.5 m Black soil 1.5 - 13m hard sand stone

APPENDIX-

VILLAGE WISE YEARLY EXPANSION OF BORE WELLS IN HUKKERI TALUK(PHE,HUKKERI)

Sl. No.	NAME OF VILLAGE	YEAR OF INCEPTION	NO. OF B.W	DIAMETER IN MM	DEPTH IN MT.	CASING LENGTH	GI PIPE LENGTH	TYPE OF PUMP	YIELD IN LTS
1	BUGATE ALUR (B.ALUR)	75	2	162	38	3.26	10 TO 12	HP	4050
		83	1	150	88	6.2		HP	8149
		86	1	150	96	6.1		15 HP	1461
		87	2	115	60	2.4		11 HP	2845
		88	1	150	122	6.6		11 HP	5125
		92	2	150	69 – 138	6.2		11 PP	13206
2	MATTIWAD (MATTIWAD	78	2	150	48–58	2.8		12 HP	5334
		82	1	150	60	3.2		14 HP	1484
		84	2	150	47–65	4.5–9.2		10 HP/PP	9944.5
		87	2	115	45–64	4–6			4327.5
		93	1	150	65	6.15		15 HP	8155
3	HITNI	75	1	162	37	3.26			6750
		81	1	150	100	3.05		15 HP	1463
		82	1	150	55	5.6		13 HP	5298
		83	2	150	61–76	3.05		11 HP	1449
		84	1	150	66	6.2		HP	8149
		85	1	150	71	6.2		12 HP	5278
		87	2	115	67–95	3		HP	1739.5
		88	1	150	166	6			8090
		89	2	150	85–218	5–6		HP	5843
		92	2	150	76–107	9.5		HP	8090
		93	1	150	251	6		18 HP	5125
4	KONANKER	77	2	150	33–55	1–1.5		10 HP	8089
		79	1	150	45	1.5			
		83	1	150	78	6		10 HP	1410
		84	1	150	68	5.6		14 HP	1439
		85	1	150	76	3.3		10 HP	8149
		86	3	150	53–100	6–14		12 HP	2253
		87	1	150	91	6.95		HP	6500
		92	1	150	109	6.1		HP	1442
		93	1	150	66	12.35		11 HP	523
5	HARGAPUR	80	2	150	55–62	7	6–18	HP	4436.5
		84	1	150	92	5	10	HP	1461
		85	3	150	34–76	3	10	HP	3537.666
		87	1	150	74	4	10	HP	1462
		88	1	150	100	6		HP	3414
		93	2	150	182–228	6–16		HP	2824
6	ANKALE	77	2	162	70–80	1–5	12	HP	981.5
		81	2	150	42–88	5–8	14	HP	5075
		84	4	150	60–92	3–6	10	HP	1455
		85	1	150	100	3	12	HP	1230
		86	2	150	98–100	9–15	10	HP	2066
		87	1	150	109	20		HP	5000
		89	4	150	69–224	6–30		HP	6088.5

7 SOLLAPUR	77	1	162 62	6		10 HP	144
	81	1	162 61	6		10 HP	1449
	82	1	150 57	9.5		10 HP	3364
	83	1	150 65	7		12 HP	3064
	85	3	150 72-101	6-12		12 HP	1238.333
	86	2	150 68-96	12-14		10 HP	1461
	87	3	150 140-152	6-16		HP	166.6666
	88	6	150 150-192	6-12.5		HP	3877.333
	89	1	150 118	6		HP	1432
	93	2	150 150-153	6-7		HP	1482
	94	1	200 228	12.5		HP	3019
8 KESTI	77	2	162 25-45	1.5		10 HP	10663
	80	1	150 24	6.75			
	82	1	150 70	6.12		13 HP	5298
	83	1	150 78	6.1		12 HP	5275
	84	1	150 74	6.1		13 HP	8150
	87	1	150 48	4.6		PP	11800
	88	2	150 45-56	6.1			5660
	92	1	150 96	5.76		PP	5170
	93	3	150 54-198	6-6.25		PP	9985
9 AKKIWAT	78	1	150 79	6.25		12	1084
	81	2	150 24-68	6	9-14		2204
	83	1	150 93	6.1		12	522
	84	1	191	5.1		12	522
	85	1	150 92	6.18		12	6700
	92	1	150 60	18.27			16765
	93	1	150 60	6.15			8155
10 ALLUR KM	77	1	162 51.2	1.5		12 HP	2601
	81	2	150 76-82	3.05		12 HP	371
	83	1	150 62	3.05		11 HP	1273
	85	2	150 97-102	3.05		12 HP	522
	92	1	150 61	6.02		PP	8155
11 BORGAL	77	2	150 47-61	1.5-3		HP	9486
	81	1	150 91	3.05		HP	517
	82	1	150 106	3		HP	517
	83	2	150 36-55	4.6-6		12 PP	10442
	85	1	150 149	6.18		15 HP	9000
	86	1	150 79	6		15 HP	1988
	87	2	150 97-105	5.4-6.3		10 HP	962
	88	5	113-150 45-183	5.8-9.7		HP,PP	4726
	93	2	150 38-202			PP	2562
12 DADDI	80	1	150 84	6.9		12 HP	1448
	83	3	150 68-84	12.3		15 HP,PP	3565
	86	2	115-150 51-76	4.24-6.1		15 HP	2793.5
	87	2	150 126-127	6-12.1		HP	3175
	88	2	150 48-161	6.14-12.4		HP	2819.5
	89	2	150 77-90	6-10		HP	2671
	90	2	150 85-128	4.59-5.09		HP	6719
	93	1	150 67	5.82		PP	5170
	94	1	150 91	9		HP	5170

13 NI... ASOSHI	75	2	150 31-32	3.26-8.5		HP	8300
	81	1	150 84	12.5		12 HP	2999
	83	4	150 56-61	6.2-9.35		10 HP	4790
	84	2	150 69-76	9.45	9-13	HP	3379.5
	85	1	150 97	3.4	15	HP	522
	86	3	150 103-118	5-6.2		HP	835
	87	3	150 50-103	5-11		HP	1033
	88	6	150 91-228	5.7-24		PP	3590
14 AMMANGI	75	2	162 61	6.62-7.61		HP	1125
	77	2	162 71-77	3.06		12 HP	258
	82	1	113 61	9.05		12 HP	3364
	83	3	150 64-92	6.1-17.5		10-12 HP	2839
	84	1	150 94	19		12 HP	1461
	85	3	150 79-176	12.4-21.3		12-16 HP	1617
	93	2	150 46-91	12.28		10-15 HP	983
15 HANDIGUD	78	1	150 61	3.07		10 HP	4540
	81	3	150 55-69	3-6.02	10-12	HP	1794
	83	1	150 84	2.15		12 HP	522
	88	2	150 117-153	3.04-5.00		HP,PP	4769
16 NERLI	72	1	150 67	6.5		HP	225
	75	2	162 68-70	2.2-3.76			
	77	3	162 78-80	3-10			
	79	2	150 92-94	3.00		15 HP	450
	83	1	150 76	3.05			
	84	1	150 101	4.57			
	86	1	150 128	6.1		15 HP	522
	87	7	150 91-153	5.96-6.5		HP	1488
	88	6	150 108-200	3.58-11.8		HP	3482
	92	2	150 155-158	6.1		PP	3287
	93	1	150 227	7.5		PP	1522
17 MASARGUF	75	2	162 90	3.3		HP	
	79	1	150 109	3.1		12 HP	1449
	84	1	150 91	3.05			
	85	1	150 154	25.4		HP	800
	86	2	150 92-97	6		15 HP	1150
	87	1	150 140	5.8		15 HP	5298
	88	1	150 133	3.15		HP	8100
	93	2	150 150-157	6.1-12		HP,PP	3274
18 KAMATNUR	74	2	150 83	6.25			113
	75	2	150 91	6.25-6.6			3291
	80	1	113 61	3.04		14 HP	1462
	83	3	150 61-91	3.05-6.25		11 HP	890
	85	1	150 150	2.25			
	86	2	150 100-106	4.51		15 HP	522
	88	2	150 228-232	12			5125
	89	2	150 178-198	6.09-13.75		12 HP	2204
	93	1	150 120	6.1			11989
	94	1	150 70	5.45			3973

19 G..ANAL	74	1	150 67	6	HP	
	75	1	162 70	3.3	8 HP	8100
	80	1	113 76	3.05	HP	
	81	3	150 82-89	3-3.05	14 HP	3709
	82	1	150 82	8.05	15 HP	1449
	85	1	150 94	6.1	12 HP	1461
	86	2	150 81-102	6.1	HP	3800
	87	1	115 117	1.95	HP	299
	88	1	150 134	6.1	HP	1441
	89	1	150 147	5.35	HP	12047
	93	2	150 173-193	6.5	HP	3282
20 GOTUR	75	2	162 91	3.3-12.42	10 HP	1467.5
	77	2	162 66	2.43-2.58	12 HP	2614.5
	80	1	113 76	3.15	14 HP	1449
	82	1	150 85	6.1	15 HP	13500
	83	2	150 79-69	6.25-12.45	12 HP	5298
	88	2	150 91-121	6-6.14	HP	9326
	93	1	150 130	6.15	HP	523
21 KOCHARI	77	2	162 79	3	HP	
	83	1	150 74	3	10 HP	2671
	84	2	150 52-92	2-6	10 HP	260
	85	2	150 92-102	3-6	15 HP	3200
	87	1	150 82	8	HP	
	89	2	150 108-154	3-5	HP	4816
	93	2	150 151-159	6-12	PP	5501
22 ARJUNWAD	78	2	150 61-85	2-3	HP	2400
	80	1	150 95	3	HP	5229
	83	1	150 75	3	HP	
	84	1	150 92	3	HP	
	85	2	150 95-97	0.5	HP	730
	86	2	150 72-97	0.5-6	HP	523
	87	2	150 54-62		HP	1754
	88	2	150 75-83		HP,PP	
	89	1	150 116	6	HP	5180
23 HEBBAL	72	1	150 57	6.8	HP	
	77	3	150 61-76	1-3.06	HP	867
	80	2	156 43-83	3.05-10.25	HP	12839.5
	88	3	150 103-124	5.5-6	HP	6690
	89	1	150 60	6.1	PP	12047
	93	2	150 126-199	12.2-12.5	HP,PP	3282
24 KURNI	72	1	150 46	6.8	HP	45400
	84	1	150 61	6.2	HP	23022
	85	1	150 70	6.1	15 HP	14977
	86	1	150 55	6.1	PP	45400
	87	1	150 126	6.3	PP	8149
	89	1	150 90	5.44	HP	12047
	90	1	150 67	6.1	HP	8155

25 U KHANAPL	73	1	162 67	12.89	15 HP	2100
	75	2	162 62	3.26	15 HP	3605
	77	3	162 24-62	2.14-4.76	HP	9648
	83	2	150 74-76	3.05-6.20	15-12 HP	5160
	85	3	150 75-102	3.05-6.35	21 HP,PP	3145
	87	1	150 116	5.7	HP	17420
	88	1	150 71.5	5.8	HP	5125
	89	1	150 123	6	HP	2937
	93	2	150 79-146	6.1	HP	5637
26 HANCHINAL	74	1	150 67.86	5.0	10 HP	4500
	77	1	162 51.37	1.52	HP	6561
	83	1	150 65.00	5.05	12 HP	1461
	85	1	150 92.20	3.15	16 HP	522
	86	2	150 85	3.45-6	HP,PP	2329
	90	1	150 1,04	4.85	HP	5000
	92	2	150 54-115	1.8-6.12	HP	725
27 CHIKKALGL	77	2	162 74-76	1.2-19	14 HP	1598
	82	1	150 85	6	15 HP	3848
	84	2	150 88	2.5-5	12 HP	3401
	86	1	150 92	6	HP	1461
	87	2	150 100-140	6	HP	2386
	88	2	150 45-178	4.95-18	HP	2838
	89	1	150 122	6.14	HP	1449
	92	3	150 118.8	6.1	HP,PP	4692
28 HATTARGI	77	1	150 41.44	3.15	11 HP	15760
	79	1	113 36.50	6.55	12 HP	5225
	81	1	150 67.1	6.15	12 HP	6396
	83	1	150 45.72	6.2	HP	1968
	85	4	150 80.5,	6.05-12.1	10 HP	2925
	86	1	150 82	6.1	PP	4894
	87	1	150 98.4	4.8	HP	3300
	89	2	150 88	5.80-5.9	HP	3898
	93	4	150 89	4.26-6.5	HP	1029
	94	1	150 85	6.22	HP	523
29 MANGUTTI	79	1	162 39.62	1.62	HP	
	80	2	115-150 60.80-77	6.20	8 HP	1540
	82	4	150 45.75-65.0	6.17-12.27	10-12 HP	3177
	84	1	150 76.2	11.8	12 HP	6172
	85	3	150 67.05-73.1	3.752-12.1	12 HP	2030
	86	2	150 61.9-83.25	6-6.1	12 HP	1725
	87	1	150 103.70	12.55	HP	1400
	88	3	150 72-94	4.5-6.0	HP-2,PP-1	3898
	89	2	150 65-104	6-21	HP	5125
	92	1	150 79.5	12.30	PP	8155

30 N/ .3NUR KC	79	1	113 77.7	3.60	10 HP	4554
	83	1	150 42.87	6.20	12 HP	2671
	87	2	150 53-90.2	5.8-6.17	10 HP	1710
	88	2	150 36-169	6.14-17.8	HP	2193
	92	3	150 72-97	5.95-6.16	HP	1641
	93	1	150 108.7	6.40	PP	11988
	94	1	150 80	6.22	HP	11989
31 SHAHABAN	81	1	150 56.73	9.00	10 HP	4176
	84	1	150 40.50	12.60	10 HP	11718
	85	2	115-150 61-46	13-30.49	10 HP	8054
	86	1	150 149	28.40	HP	
	93	1	150 60	6.20	HP	2959
32 BASAPUR	80	2	113-150 24.00-30.4	6.4	8 HP	450
	81	1	150 82.15	29	10 HP	11717
	85	4	150 91.44-97.4	7.1-21.00	12 HP	946
	93	4	150 25-121.9	6.15-27.42	HP-3,PP-1	2491
33 KARAGUPP	80	2	113 34-37	3.05-6.5	12 HP	400
	84	1	150 93.4	15.3	12 HP	1461
	85	1	150 74	19.4	12 HP	1461
	85	2	150 67-76.25	5.94-6.1	HP	2204
	90	1	150 61	20.12	HP	16741
	93	2	150 73.2-121.9	7	HP	16741
34 CHILLBAVI	83	1	150 30.5	3.05	10 HP	5325
	85	1	150 62	3.00	12 HP	522
	93	1	150 81	9.0	15 HP	5296
35 GODGERI	80	3	113	7-9.15	HP	708
	81	1	150 60.96-70	12.54	12 HP	3090
	82	1	150 86.25	3.05	10 HP	3583
	83	1	150 54	6.04	12 HP	2250
	84	1	150 71	9.10	12 HP	1461
	85	1	150 65	9.1	12 HP	8149
	86	3	150 65.5-74	6.1-9.1	10 HP-2,PP-1	1597
	87	3	150 91-91.5	2.14-6.16	HP	2320
	88	2	150 50-60.05	6.10-6.14	HP,PP	4065
	89	1	150 84	5.80	HP	5125
	93	1	150 60	6.3	HP	525
36 NADDIGUDI KETRA (GODGERI)	79	1	113	26 1.37	HP	
	80	1	113	24 3.05	HP	2250
	81	1	150	81 5.00	HP	832
	86	1	115	45 5.1	HP	5170

37 MADDIHALI	77	2	162 55-70	2-3		10 HP	14591
(MADDIHAL	81	2	113-150 30-77	3-6		16 HP	2250
	82	1	150 73	6		16 HP	2764
	84	3	150 61-75	3-10	10-12	HP	3690
	86	1	150 85	6		15 HP	2819
	87	1	150 62	6		HP	1400
	89	3	150 69-128	6-6.5		HP-1,PP-2	8103
38 SHIRGAON	77	3	162 62-74	2.5-3.5	10-12	HP	3852
(MADIHALLI	80	1	150 75	6.1	14	HP	1449
	83	1	150 74	6.2	12	HP	1482
	84	1	150 67	6.25	12	HP	1432
	85	2	150 56-76	3.6	12	HP	2910
	87	1	150 137	5.5	15	HP	10800
	89	1	150 55	5.8		PP	16740
	92	2	150 48-121	6.1		HP,PP	11957
39 KOTABAGI	79	1	162 48.5			10 HP	4554
(KOTABAGI	84	1	150 15.5			HP	8149
	85	1	150 3.0			HP	1461
	86	1	150 45.6	3		HP	2700
	88	3	150 45-164	2.7-12		HP-1,PP-2	7752
	93	1	150 63	6.2		PP	8170
40 RAKSHI	77	2	150-162 61-67	1.5-2.5	9-16	HP	8868
(KOTABAGI	81	1	150 76	3	15	HP	1701
	84	1	150 93	4.2	17	HP	2871
	86	1	150 106	6.1	12	HP	522
	87	1	150 141	5.5	12	HP	5298
	93	1	150 63	6.1		HP	1442
41 GUDAS	73	2	150 59-74	3-9		9 HP	5093
(GUDAS)	78	1	150 70	5.75		12 HP	2691
	81	2	150 62-93	6.11		HP,PP	5863
	83	1	150 92	3		HP	
42 HULLOLI	72	2	150 52-68	6.44		HP	10100
(HULLOLI)	77	1	150 79	1.85		HP	1449
	81	3	150 56-93	2.3		12 HP-2,PP	3590
	85	1	150 91	6.1		PP	8149

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