DISTRICT GROUND WATER BROCHURE
AGRA DISTRICT, UTTAR PRADESH

(A.A.P.: 2012-13)

-By-

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CONTENTS

DISTRICT AT A GLANCE
AGRA DISTRICT, UTTAR PRADESH

1.	**GENERAL INFORMATION**			
	i.	Geographical Area (Sq km)	:	**4027 sq. km.**
	ii.	Administrative Divisions (2007-08) Number of Tehsil/Block Number of Panchayat/Villages City/Towns	:	Tehsils-06, Blocks-15, Nyaya Panchayat-154, Gram Sabha- 640 , Villages – 941, City/Towns- 17
	iii.	Population (As on 2001 Census)	:	3623297 (Male – 1962813 and Female- 1660484), Male Female Ratio=846, Rural Population= 2055588, Urban Population= 1567709
	iv.	Annual Normal Rainfall (mm)	:	751.37
	v	**Average Temp.**		**Max. 34.85^{0}C , Min. 16.2^{0}C**
2.	**GEOMORPHOLOGY**			
	Major physiographic units		:	1-Alluvial Plains(occupying the major part of district) 2-Ravines 3-Structural Valleys and 4- Structural Hills
	Major Drainages		:	Dendritic Type – Mainly constituted of Yamuna and it s tributaries viz. Utangan or Gambhir and Khari. Chambal is another important perennial tributary of Yamuna.
3.	**LAND USE (Sq Km) (2010 –11)**			
	a)	Forest area	:	356.91
	b)	Net area sown	:	2827.91
	c)	Gross area sown	:	4246.94
		Cropping Intensity		150%
4.	**MAJOR SOIL TYPES**		:	Sandy loam, loam, clayey loam and rocky of various colours; which varies from fine to coarse in texture (Agra I to VI type)
5.	**GROSS AREA UNDER PRINCIPAL CROPS (Sq.km) (Year: 2011-12)**		:	Rabi – 2649.90, Kharif – 1483.98, Jayad- 113.06
6.	**IRRIGATION BY DIFFERENT SOURCES (Areas in Ha) - 2010-11**			
	Dugwells (Total No. 1749)		:	230 Ha

	Tubewells/Borewells	:	Govt.TW (Total No. 317) = 5012 ha, Private Tube Well / Bore Wells with Pumpsets (Total No.-68116)=224738 Ha
	Canals	:	(Total Length 737 Km) 28375 ha
	Other sources	:	Ponds = 289 ha, Others = 56 ha
	Net Irrigated area	:	258700 Ha
	Gross irrigated area	:	283645 Ha
	Irrigation Intensity		110%
7.	**NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31.3.2013)** **No of Dug Wells** **No of Piezometers (Pz of GWD, U.P. and C.G.W.B. monitored at N.H.S.)**	 : :	 09 12
8.	**PREDOMINANT GEOLOGICAL FORMATIONS**		Mainly thick pile of Quaternary Alluvial sediments, with restricted patches of Vindhyans (Formations ; Quartz, Arenite, Sandstone, Shales, and Limestones) outcrops of Proterozoic period.
9.	**HYDROGEOLOGY And AQUIFER GROUP**		The Aquifer System is by and large of Two Tier and mainly constituted of Sand and Gravel up to maximum explored depth of 231 mbgl . In the marginal alluvial plains lying in the south western part of the district , the Aquifer system is mainly constituted by the joints, fractures in Sandstones/quartzites and overlying alluvium/weathered mantle.
	Major Water bearing formation	:	Sand, Gravel, Fractured sandstone/ quartzite, weathered mantle
	Pre-monsoon Depth to water level during May' 2012 (N.H.S. Data)		2.19 to 45.58 mbgl
	Post-monsoon Depth to water level during Nov'2012	:	1.10 to 46.34 mbgl

	Long term water level trend in 10 years (2003-12) in m/year	:	**Pre-monsoon :** Fall 0.1777 to 1.3403 m/year, Rise 0.0140 to 0.7912 m / year **Post-monsoon:** Fall 0.0440 to 1.5872 m/year, Rise 0.2390 to 0.4595 m/year
10	**GROUND WATER EXPLORATION BY CGWB (As on 31-3-2013)**		
	No of wells drilled (EW, OW, PZ, SH, Total)	:	Exploratory Well - 17, Observation Well- Piezometer-08, Slim Hole - 01
	Drilled- Depth Range (m)	:	EW- 64.00 to 183.49 mbgl, PZ – 45.00 to 223.00mbgl, SH – 128.00mbgl
	Discharge	:	250 to 3406 lpm
	Storativity (S)	:	**$4.8x10^{-6}$ to $8.5x10^{-4}$**
	Transmissivity (m^2/day)		**25 to 1205 m^2 /day**
11.	**GROUND WATER QUALITY**		
	Presence of Chemical constituents more than permissible limit (e.g. EC, F, As, Fe)	:	The Ground Water resources of the shallow Aquifers are in general of Permissible class except higher concentration of Flouride (>1.5mg/lit.) and higher values of EC at so many places. However, the quality is deterioted in deeper aquifers and it is brackish to saline at so many places.
	Type of water		Generally fresh in shallow aquifers, Fresh and Brackish to Saline in deeper zones.
12.	**DYNAMIC GROUND WATER RESOURCES (2009) – in MCM**		
	Net Annual Ground Water Availability	:	991.70
	Existing Gross Annual Ground Water Draft for all uses	:	952.55
	Projected Demand for Domestic industrial Uses up to 2025	:	85.60
	Stage of Ground Water Development	:	District = 96.05% (Block wise range = 36.95 to 179.16%)
	Net Ground Water Availability for Future Irrigation Development		19.70

13.	**AWARENESS AND TRAINING ACTIVITY**		
	Mass Awareness Programmes organized		Nil
	Date		-
	Place		-
	No. of participants		-
	Water Management Training Programme organized	:	NIL
	Date		-
	Place		-
	No of participants		-
14.	**EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING**		
	Projects completed by CGWB (No & Amount spent)		NIL
	Projects under technical guidance of CGWB (Numbers)		NIL
15.	**GROUND WATER CONTROL AND REGULATION**		
	Number of OE Blocks	:	06 (Akola, Bharauli Ahir, Bichpuri, Fatehpur Sikari, Khandauli, Shamsabad)
	No of Critical Blocks	:	01 (Saiyan)
	No of blocks notified	:	NIL
16.	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	:	Significant Decline in Water Level, Ground Water quality problem viz. occurrence of Flouride element beyond permissible limit, occurrence of Brackish to Saline Ground Water in deeper zones at so many places. Comparatively less ground water recharge and more surface run off of Monsoon rain fall is another problem which consequently resulting declining in water level, this may be arrested by adopting artificial ground water techniques, especially in urban areas. Artificial Ground Water Recharge may also improve Ground Water quality.

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I. INTRODUCTION

Ground water is playing a vital role in the fulfilment of drinking, irrigational and industrial needs of the area, as it is the highly dependable, safe and a replenishable natural resource.. Agra district is a universally well-known place because of Taj Mahal, one the seven wonders of the world. Being an important tourist place, the needs of drinking water in the metropolis have been increased manifold. Side by side, due to occurrence of brackish to saline ground water pockets at varying depths and increasing pollution in surface. Water and also in ground water resources, the water supply is becoming a grave problem day by days specially in urban areas. It appears that populace of this region are facing the drinking water problems due to salinity in ground water from ancient times. Presently many agencies are working to solve the water supply problems of Agra metropolis and it's rural areas.. For the proper ground water development of an area, the knowledge of the regional hydrogeology, available ground water resource potential, status of its utilization and quality of the formation water is quite essential.

The Agra district encompasses an area of 4027 Sq. Km. in Indo-Gangetic plain and its major part (about 80%) is occupied by Quaternary alluvium. However, Vindhyan rocks (Bhander sandstone) are exposed only in the western and south-western parts of the area. The granular zones consisting mainly of alluvial sands and gravels forming the two tier aquifer system in the area. These aquifer have Transmissivity (T) varying from 25 to 1205 m^2/day whereas permeability (K) values ranges between 17.25 and 18.22 m/day.

The depth to water level in phreatic aquifer varies from 7.23 to 31.14 mbgl during pre-monsoon period and the water level fluctuation between pre and post-monsoon period varies from 0.00 to 7.00 meters Rise, and 0.00 to 0.30 m Fall in 2012. The long term behaviour of water table shows declining trend in the major part of the area, only the canal command areas are depicting somewhat rising trend. In general, the elevation of water table varies from 120 to 185 mamsl with a master slope from northwest to southeast, and hydraulic gradient ranging between 0.20 and 4.00 m/km. The major rivers viz. Yamuna, Chambal & Utangon, are of effluent type. The ground water resources of the phreatic aquifer occurring down to 50 mbgl in the area are generally potable & suitable for irrigation purposes, except in few pockets where the salinity in ground water exists from the ground surface. The deeper aquifers in the entire district are generally trending to be brackish to saline. The net ground water availability in the district is 99170 ham. & present annual draft for all uses is 95255 ham. thus leaving a balance of 1970 ham for futer irrigation development. Considering the level of ground water development, the six (06) blocks viz. Akola, Barauli Ahir, Bichpuri, Fatehpur Sikari, Khandauli, and Shamsabad have been categorized under Over Exploited. The only one block viz. Saiya has been determined as 'Critical', three blocks viz.Achhnera, Jagner, and Khairagarh are semi-critical, and remaining all 05 blocks are falling under 'Safe' category. Therefore there is a limited scope for the future ground water development in the entire district..

1.1 Location Extent and Accessibility :

The Agra district occupies the western most part of the Uttar Pradesh. The district is bounded by the Rajasthan and Madhya Pradesh states in the west & south and by Mathura, Etah, Firozabad, Mainpuri and Etawah district from north to east respectively. It encompasses an area of 4027 Sq. Km, and lies between latitude $26^0$44'10", to $27^0$24'30" North and longitude $77^0$30'15" to $78^0$51'30" East under the Survey of India toposheet Nos. 54 E, F, I and J (Plate-I). The district is well connected by roads and train routes.

1.2 Administrative Division :

The Agra district is divided into six (06) tehsils viz. Kiraoli, Agra, Etmadpur, Khairagarh, Fatehabad and Bah. The district is further sub-divided into 15 developmental blocks.

1.3 Demography :

The total population of the Agra district is 3623297 (As per 2001 census) out of which about 57% rural populace are living in 941 villages and remaining 43% urban population in 17 towns /cities. The male/female ratio is 846 in the entire district. The population density is high (8173/Sq. Km.) in the urban and less (536/Sq. Km.) in the rural areas. The decadal population increase is 25.35% in the district.

1.4 Previous Work :

In the Agra district hydrogeological investigation & surveys have been carried out time to time by the geologist/scientist/engineers of GSI, CGWB, GWD and other state agencies. The area has already been covered under systematic hydrogeological surveys by the Central Ground Water Board. The ground water management studies in the district were carried out by the Central Ground Water Board in the year 1999-2000. Under it's ground water exploration/deposit well programme, the CGWB carried out deep drilling and constructed so many tube wells in the district. Besides, U.P. Jal Nigam, and state Irrigation Department have constructed a number of shallow and moderately deep tube wells for domestic and irrigation water supply.

II. GEOGRAPHICAL FEATURES

The geographical features of the study area may be classified broadly into Human and Physical characteristics. The physiography, drainage, climate and soils are the main physical features, whereas the land use, agriculture, irrigation and population are the basic subjects under the Human geographical features.

2.1 Physiography :

The area of the Agra district occupies marginal alluvial plain of Yamuna and Chambal rivers. The area is more or less flat and gently sloping from northwest to southeast. The altitude of the area generally varies from 120 to 190 mAMSL. Geomorphologically the entire study area may be divided into four units viz. Alluvial plains, Ravines, Structural valleys and structural hills. The Alluvial plain covers the major part of the district and is characterized by the more or less flat topography with the landforms like dry river beds, older meanders, meanders scars and oxbow lakes. It is a tract of fertile land mainly constituted of clay, silt, sand, gravel and secondarily developed kankar concretions. The second geomorphological unit is the ravinous land tract developed mainly in the Yamuna Chambal Doab. It is characterized by the network of deep gorges and gullies developed due to long process of land erosion due to fluvial activities and also by the unfertile soils with the predominance of silt and clay sediments. The structural valleys, the third geomorphological unit of the area, are linear to curvilinear and northwest to southeast trending features and are exposed mainly in the Fatehpur Sikri, Achhnera an Jagner blocks. These features have developed as a result of faulting and fracturing and filling of weathered mantle/Alluvium at later stages.

The fourth geomorphological unit is the structural hills, which are mainly exposed in the Kiraoli, Jagner, Fatehabad and Fatehpur Sikri blocks. These are characterized by the chain of linear narrow ridges and detached hillocks and constituted of almost horizontally dipping hard and compact Bhander Vindhyan sandstones Elevation of these rocky surfaces varies from 217 m to 300 m. Among these structural hills, the Fatehpur Sikri ridge is well known mainly due to the quarries of reddish Bhander sandstones, which was used in the construction of Agra Fort, Buland Darwaza and other important historical buildings in Agra and Delhi.

2.2 Drainage :

The drainage system of the area is controlled by the river Yamuna and it's tributaries. All the rivers are mainly flowing in accordance with the general slope of the land surface viz. northwest to southeast, therefore it is consequent types and broadly exhibiting the 'Dendritic type' of drainage pattern. The main southern bank tributaries of the Yamuna river are Utangan or Gambhir & Khari. The Chambal river is also a very important perennial tributary of Yamuna flowing from West to East forming the southeastern boundary of the district. The Chulhai, Lohenrhi, Bisundri and Kowar are the main tributaries of Utangan river draining the rocky terrain of Jagner block in the southwestern parts of the area. The Khari Nadi is also a tributary of Utangan draining the parts of Kiraoli and Shamsabad tehsils. The Karoan is a seasonal northern bank tributary of the Yamuna draining the northeastern parts of the study area. The comparatively high lands, situated in the middle parts of the Doabs of Yamuna-Khari, Khari-Utangan and Yamuna-Chambal, are acting as the water divides. The ravenous areas along the northern bank of Chambal and along the southern bank of Yamuna under Bah tehsil has intricate network of minor rivulets and gullies through which the drainage of the surface water during monsoon periods takes place. It has been observed that discharge of Chambal river in summer is comparatively more than the Yamuna river.

2.3 Climate and Rainfall :

The area falls under sub-humid climate and characteristics of vegetation is grassland. The Precipitation Effectiveness value calculated by Thornswaite C.W Precipitation Effective Index Method (1958) based on total monthly rainfall and mean monthly temperature determine the climate. The same is expressed as :

$$P.E. = 115 (P/T-10)^{10/9}$$

Where, P.E. is monthly precipitation effectiveness

P is total monthly rainfall in inches

T is mean monthly temperature in ^{0} farenhight

For calculating the yearly P.E. Index, all the twelve months P.E. value is added. The climate type is based on yearly P.E. Index as follows :

Table-I

Humidity province	Characteristic vegetation	Annual P.E. value
Wet	Rain forest	>128
Humid	Forest	64 to 127
Sub-Humid	Grass land	32 to 63
Semi-Arid	Stopple	16 to 31
Arid	Desert	<16

For calculating the P.E value the Temperature and Rainfall data of Agra Observatory is taken into consideration on the basis of Normal values of Rainfall and Temperature of Agra Observatory, Annual P.E. Index is 35.91. This shows that area comes under sub-humid climate. The Climatological data of the Agra Observatory is given in the following table –

Table-II

CLIMATOLOGICAL DATA OF THE AGRA DISTRICT, U.P.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean/Total**
Temp (^{0}C)													
Max.	22.2	25.7	31.9	37.7	41.8	40.5	34.8	32.8	33.2	33.3	29.2	24.1	32.27
Min.	7.4	10.3	15.7	21.6	27.2	29.2	27	25.8	24.6	19.1	12	8.2	19.01
Average	**14.8**	**18**	**23.8**	**29.65**	**34.5**	**34.85**	**30.9**	**29.3**	**28.9**	**26.2**	**20.6**	**16.15**	**25.64**
Relative Humidity (%)	**59**	**48**	**35.5**	**25**	**25.5**	**41**	**70.5**	**78**	**69.5**	**48.9**	**47**	**54**	**50.16**
Monthly Rainfall (mm)	16.2	8.8	10.9	5.3	10	60	210.2	263.2	151.5	23.5	2.1	3.7	765.40
P.E. Value	0.935	0.423	0.437	0.167	0.294	2.204	9.567	12.798	7.777	1.058	0.078	0.171	35.91
Potential Evapotranspiration (mm)	52.9	75.2	126.4	162.6	208.3	204.4	145.8	123.9	132.9	116.1	68.7	49.7	1466.90
Wind Speed (Kmph)	3.6	4.2	4.9	5.1	5.9	6.9	5.8	4.9	4.5	3.2	2.6	2.9	4.54
No. of Rainy Days	1.6	0.9	1.1	0.6	0.5	2.9	10.6	12.2	6.6	1.3	0.3	0.4	39.00

Also, the Normal rainfall data of the Agra district is shown in the following table

Table-III

NORMAL RAINFALL DATA OF AGRA DISTRICT, U.P.

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Non-Monsoon	Monsoon
Agra	14.4	10.9	8.6	4.7	8.4	50.8	208.4	239.6	131.4	23.2	4.9	5.7	711	80.8	630.2
Fatehpur Sikri	13.9	9.7	7.5	3.4	6.1	42	193.7	227.5	133.2	23.3	3.9	5.4	669.6	73.2	596.4
Khairagarh	16.5	12.9	10.4	5.3	7.1	44.6	221.5	270.5	163.6	31.2	5.3	6.6	795.5	95.3	700.2
Bah	15.9	10.8	9.1	5.6	8.4	60.3	235.2	241.8	143.8	26.8	3.9	6.3	767.9	86.8	681.1
Etmadpur	15	12.2	8.6	4.4	10.5	51.6	198.9	215.3	129.1	26.4	3.2	4.6	679.8	84.9	594.9
Bhikhapur	10.4	8.9	7.4	3.2	3.4	42.5	173.4	217	119.3	20.3	3.2	3.7	612.7	60.5	552.2
Fatehabad	12.62	13.2	11.8	5.6	7	49.5	206.5	260.2	160.2	33.4	4.5	6.6	771.12	94.72	676.4
Average	**14.10**	**11.23**	**9.06**	**4.60**	**7.27**	**48.76**	**205.37**	**238.84**	**140.09**	**26.37**	**4.13**	**5.56**	**715.37**	**82.3**	**633.1**
Standard Deviation	**1.92**	**1.50**	**1.46**	**0.92**	**2.05**	**5.95**	**18.36**	**19.37**	**15.34**	**4.30**	**0.75**	**1.01**	**61.19**	-	-
Co-Var.	**13.62**	**13.33**	**16.12**	**20.03**	**28.20**	**12.21**	**8.94**	**8.11**	**10.95**	**16.29**	**18.16**	**18.17**	**8.55**	-	-

The annual normal Rainfall (1901-1970) of the district comes to 715.84 mm. The maximum rainfall occurs during the monsoon period i.e. June to Sept. having the normal value of 633.1 mm which is 88.44% of annual rainfall. August is the wettest month having the normal rainfall of 238.84 mm followed by July with normal rainfall of 205.37 m.m. The hottest month is June with average mean temperature of 34.85^0C followed by May with 34.5^0C. The coldest month is January with average mean temperature of 14.8^0C followed by December with 16.15^0C. The highest % of humidity occurs in the month of August with normal relative humidity of 78% followed by 70.5% in July. The normal annual mean wind speed of the district is 4.9 Kmph. The highest normal wind speed is 6.9 Kmph in the month of June followed by 5.9 Kmph in May. The Annual normal Potential Evapotranspiration of the district is 1467.2 mm. The maximum PET occurs in the month of May and June with 208.3 mm and 204.4 mm respectively.

2.4 Soils :

The soils of the study area exhibits great variance mainly due to the influence of different rivers and variation in the provinance of the sediments. On the basis of constitution, physical & chemical properties and texture, the soils of the district may be classified broadly into the following six categories.

Agra-I Type Soils :

Agra-I Type soils are occurring adjacent the banks of Yamuna in the Agra, Fatehabad, Etmadpur and Bah tehsils. It has coarse sandy texture and grey to ash grey colour.

Agra-II Type Soils :

Agra-II Type Soils are occurring in the undulating topographical uplands of Karaoli, Khiragarh and Fatehabad tehsils. It is light textured brownish to yellowish coloured soil and dry in appearance. The Jwar, Bajra and Arhar are the main crops grown in this soil type.

Agra-III Type Soils :

Agra-III Type Soils are mainly occurring in uneven to plain regions along Khari river. This type is loamy to clayey loam textured, grey to greyish brown coloured soil of good granular structure with occasional occurrence of Kankar pan.

Agra-IV Type Soils :

Agra-IV Type Soils mainly occurs in the depressions, and has been insignificantly found in the area of study. It is generally fine textured very hard & compact grey to dark grey in colour.

Agra-V Type Soils :

Agra-V Type Soils has been developed in the ravinous tracts of Chambal river in Bah tehsil. It is fine textured, black coloured soil of highly calcareous nature, and generally develops numerous cracks & fissures on drying.

Agra-VI Type Soil :

Soil is mainly found in the south & southwestern corner of Khairagarh in parts of Kiraoli tehsils. It generally occurs adjacent to rocky out crops near Fatehpur Sikri and is comprised of mainly undecomposed rocky fragments of sandstone. This reddish brown soil is sandy in texture.

2.5 Land Use Pattern :

The total area of the Agra district is 4027 sq. km., out of which 3835.20 sq. km. is rural, and 191.80 sq. km. urban. The total reported area is 398970 hectare,

Table - IV

LAND USE PATTERN IN AGRA DISTRICT, U.P. (Area in Hectares)

S. No.	Block	Total reported area	Forest	Barren Culturable waste land	Present Fallow land	Other fallow land	Barren and unculturable land	Land used other than agriculture	Pasture land	Area under bush, forest, & gardens	Net area sown	Gross sown area	Cropping Intensity (%)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	12	*13*	*14*
1.	Fatehpur Sikri	29130	656	150	289	192	311	2136	75	552	24769	37443	151
2.	Achhnera	28153	840	75	259	226	221	2928	32	272	23300	35695	153
3.	Akola	17123	105	57	401	237	141	1913	34	209	14026	22270	159
4.	Bichpuri	11753	755	145	1567	187	224	2160	12	472	6231	9611	154
5.	Barauli Ahir	24006	87	121	1873	759	142	3101	48	447	17428	28920	166
6.	Khandauli	21611	342	122	1184	460	106	1644	6	394	17353	25535	147
7.	Etmadpur	22123	186	58	238	182	80	1850	62	229	19238	28891	150
8.	Jagner	29371	3092	230	1428	309	798	1678	77	1152	20607	25448	123
9.	Khairagarh	24833	1044	52	823	214	242	1748	219	447	20044	28605	143
10.	Saiyan	23084	187	124	826	311	99	1765	182	399	19191	27934	146
11.	Shamsabad	26852	362	135	603	141	312	1830	3	992	22474	37218	166
12.	Fatehabad	33866	3336	216	2346	474	406	1890	104	850	24244	41195	170
13.	Pinahat	28975	7234	132	907	427	274	2798	15	359	16829	21269	126
14.	Bah	27077	6514	130	1229	374	202	2037	11	382	16198	23786	147
15.	Jaitpur Kalan	30540	9909	126	2848	114	149	2590	0	372	14432	20860	145
	Total Rural	378497	34649	1873	16821	4607	3707	32068	880	7528	276364	414680	-
	Total Urban	0	0	0	0	0	0	0	0	0	0	0	-
	Total Forest	20473	1042	508	1922	482	242	8877	16	957	6427	10014	-
	Total District	398970	35691	2381	18743	5089	3949	40945	896	8485	282791	424694	**150**

out of which 70.88% is under cultivation. The remaining 29.5% area is mainly in the form of barren culturable waste land, fallow land, other fallow land, barren unculturable land, and land used other than agriculture. With proper scientific approach (i.e. land and water management), the present culturable waste land and barren land may be developed in future for agriculture purposes Table–IV.

2.6 Agriculture :

Agriculture is the main business of about 09 % of the total population of the area. Therefore, about 70% of the total reported area is under the agriculture use. Out of the total reported area the maximum percentage of the net sown area is in Etmadpur (87%) and Fatehpur Sikri (85%) blocks whereas the minimum percentage is in Jaitpur Kalan (47.26%) and Bichpuri (53%) blocks. . Out of the net sown area about 50% area is sown more than once. The cropping intensity in the district is 150%, whereas it is maximum in the Fatehabad (170%) and minimum in Jagner (123%) blocks. The Rabi, Kharif and Jayed are the main cropping seasons of the area. The Wheat, Barley, Gram, Pea are the main Rabi crops, whereas the Paddy, Jwar, Bajra, Corn & Groundnut are the main Kharif crops. Some Jayed crops are Urad, Moong, Sawan and Corn. Other important crops of the area are Sugarcane, Arhar, Sun Flower and Soyabeen.

2.7 Irrigation :

The surface as well as Ground Water resources are in the use for the irrigation purposes. The canals are the main source of surface water irrigation. The Agra canal and it's distributaries viz. Sikandara, Fatehpur Sikri and Agra distributary constitute the main canal network in the area.The total length ofcanals in the district is 737 km.

About 28375 hact. net area is under canal irrigation which is about 10% of the total net sown area, and 11% of the net irrigated area. . The percentage of net irrigated area under canal irrigation is comparatively more in Achhnera (34%), Khairagarh (19%), Fatehpur Sikri (28%) and Bichpuri (20%) blocks, and less in the Etmadpur (2%), Siya (3%) and Shamsabad blocks. At present, the canal irrigation is nil in Khandauli, Jagner and Fatehabad blocks. Irrigation by Tank/Lake water is also in practice at minor level in Akola and Achhnera blocks.

The state tubewells (Total No. 317), shallow tubewells-Electric Run(11676) and borings fitted with pumping set-Diesel Run(No. 54950), other Pumping sets

(No.1490), dug wells (No. 1749) & Persian Wheels (No. 30) are the main hydraulic structures used for extracting the ground water resources for irrigation and other uses. The private tubewells and borings are popularly used structures due to their comparatively lesser cost of construction, easy maintenance and effective irrigation capacity. Nowadays, the irrigation by persian wheels is almost obsolete and only in practice in the Jagner block of the study area. The Dug Wells are still in use and about 230 hact. Area of the district is irrigated by these structures. In the district about 229980 hact. net area is irrigated by ground water resources, which is about 81% of the total net sown area, and about 89% of the total net irrigated area. Presently, ground water is the only source of irrigation in Khandauli, ,Jagner and Fatehabad blocks. Blockwise review of the irrigation status shows that out of the net irrigated area, the percentage of net irrigated area by ground water resource is 100% in Khandauli,Jagner, and Fatehabad blocks and comparatively more (above 90%) in Saiya, Shamsabad, Bharauli Ahir, & Bah blocks and less in Achhnera (65%), Khairagarh (80%) and Fatehpur Sikri (72%) blocks. In the entire district overall irrigation intensity is 110%, which may also be increased to the ultimate target of 200% by developing Ground Water & Surface Water resources conjunctively. In the entire district about 09% of the net sown area in still un-irrigated which may be brought under irrigation in future by the development of water resource.

Table-V

AGRICULTURAL STATISTICS AGRA DISTRICT, U.P.

(Area in Hect.)

S. No.	Block	Total reported area	Net sown area	Sown area more than once	Gross sown area	Gross sown area under Rabi crops	Gross sown area under Kharif crops	Gross sown area under Jayed crops	Cropping intensity (%)	Net irrigated area (Ha)	Gross irrigated area (Ha)	Net irrigated area only by surface water resources (Ha) (Percentage from Net irrigated area)	Net irrigated area only by groundwater resource(Ha) (Percentage from Net irrigated area)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1.	Fatehpur Sikri	29130	24769	12674	37443	24186	12855	402	151	23844	26325	6693 (28%)	17151(72%)
2.	Achhnera	28153	23300	12395	35695	21130	13390	1175	153	21130	25494	7473 (35%)	13657(65%)
3.	Akola	17123	14026	8244	22270	13441	7876	953	159	13441	19956	2441 (19%)	11000(82%)
4.	Bichpuri	11753	6231	3380	9611	6231	2948	432	154	6231	7585	1275 (20%)	4956(80%)
5.	Barauli Ahir	24006	17428	11492	28920	17428	10118	1374	166	17428	19956	1173 (07%)	16255(93%)
6.	Khandauli	21611	17353	8182	25535	17015	7379	1141	147	16780	18103	0.0	16780(100%)
7.	Etmadpur	22123	19238	9653	28891	19060	8651	1180	150	19060	20633	421 (02%)	18693(98%)
8.	Jagner	29371	20607	4841	25448	19269	6177	2	123	15230	15389	0.0	15230(100%)
9.	Khairagarh	24833	20044	8561	28605	18868	9483	254	143	18608	19773	3592(19%)	15016(81%)
10.	Saiyan	23084	19191	8743	27934	18424	9279	231	146	18286	19090	523(03%)	17763(97%)
11.	Shamsabad	26852	22474	14744	37218	21566	13681	1971	166	21513	25414	777(04%)	20736(96%)
12.	Fatehabad	33866	24244	16951	41195	23679	16178	1338	170	23490	25331	0.0	23490(100%)
13.	Pinahat	28975	16829	4440	21269	12374	8742	153	126	12140	12297	1364(11%)	10776(89%)
14.	Bah	27077	16198	7588	23786	13236	10228	322	147	12848	13175	945(07%)	11903(93%)
15.	Jaitpur Kalan	30540	14432	6428	20860	12219	8396	245	145	11930	12084	1139(10%)	10791((90%)
Total Rural		378497	276364	138316	414680	258126	145381	11173		251959	280605	27816(11%)	224143(89%)
Total Forest		0	0	0	0	0	0	0		0	0	0	0
Total Urban		20473	6427	3587	10014	6864	3017	133		6741	3040	848(13%)	5893(17%)
Total District		**398970**	**282791**	**141903**	**424694**	**264990**	**148398**	**11306**	**150**	**258700**	**283645**	**28664(11%)**	**230036(89%)**

III. GEOLOGY

3.1 Geology :

The district of Agra occupies a part of Indo-Gangetic plain and its major part is underlain by alluvial sediments of Quaternary age comprising mainly a sequence of clay, silt, sand of different grades, gravels and kankar in varying proportions. The alluvium was deposited over the slopes of the basement of Vindhyan rocks e.g. sand stone, shale, silt stone etc. The generalised geological succession is as follows :-

Period	Age	Group	Lithology
Quaternary	Holocene	Newer Alluvium	Fine to medium grained micaceous sand with sub-ordinate silt & clay
	Middle to Late Pleistocene	Older Alluvium (Varanasi Alluvium)	Oxidised, Khaki to brownish yellow silt, clay with kankar dessiminations, and grey to brown fine to medium grained sand.
----------Unconformity----------			
Proterozoic-III	Vindhyan Super group		Upper Bhander sandstone with shale, siltstone, shale pebble conglomerate.

The district is mostly covered by a thick pile of Quaternary sediments with restricted patches of outcrops of Vindhyan super group. Vindhyan Super Group consists of rocks of Bhander group, which includes white to purple quartz arenite, medium to fine grained purplish to reddish spotted and laminated sandstone with inter mittent partings of shales, shale pebble conglomerate, siltstone and greenish sandstone. This Vindhyan super group belongs to Proterozoic-III age.

These sand stones are exposed viz. (i) in the form of strike ridge between Dhanauli and Sirauli at Fatehpur Sikri having a dip about 30^0 due Southeast (ii) in the form of continuous ridge from Basai to about 2 Km northeast of Kudhara, dipping 3^0 to 6^0 northeast and coinciding almost with the state boundary (iii) in the form to continuous ridge from Chachand firstly trending east to northeast, then easterly and finally swinging to southeasterly direction between west of Kharpur and Sarangpur. These rocks generally have a southerly dip varying from 10^0 to 20^0 (iv) In the form of discontinuous ridge between Nayagaon and Udaina through Jagnair and Noni. Around

Nayagaon these formations have rather a flatter disposition, but in northeast of Jagner these are dipping at an angle varying from 10^0 to 15^0. These upper Bhander sandstones are hard, compact, mostly fine-grained, well-bedded, prominently jointed reddish in colour. These sandstone bear three types of joints viz. bedded joints, vertical joints and the master joints. The master joints appears to persist vertically up to varying depths.

The alluvium of Quaternary age occupies the major part of the district. On the basis of age and its constituents, it may be further classified as Older Alluvium, and the Newer Alluvium. All these sedimentary formations were deposited as the valley fills unconformably on the Vindhyan Sandstones during the middle to late Pleistocene and Holocene times and are comprising of different grades of sands, silts, clays, gravels and secondarily developed calcareous nodules known as kankar.

The older alluvium is represented by Varanasi Alluvium of middle to late Pleistocene age. The Newer Alluvium of Holocene age comprised of two units viz. (i) Terrace alluvium and (ii) Channel alluvium.

The Varanasi Older Alluvium is a Polycyclic sequence of oxidised, brownish yellow silty-clay with kankar disseminations, and grey to brown fine to medium grained micaceous sand showing laminations, ripple marks and cross beddings. It has been further classified into silt clay facies and sand facies. Silt clay facies cover major part of the district.

The channel alluvium is confined to present banks of Chambal, Yamuna and Gambhiri rivers, while the terrace Alluvium is exposed only along the Yamuna and Gambhiri rivers.

3.2 Sub-Surface Geology :

The sub-surface geological configuration of sediments has been studied and the hydrogeological data of the exploratory tubewells constructed by C.G.W.B. in the district is presented in Table-VI.

A perusal reveals that the thickness of the alluvium varies in accordance with bedrock topographical configuration. The thickness of alluvial pile is comparatively less in the areas of marginal alluvial plains i.e. around the Vindhyan outcrops and ridges, than the valley fills.

In general, the Vindhyan basement is occurring at the shallower depths (64.00 to 126.00 mbgl) in the western and southwestern parts of the district, the depth

gradually increases towards the northeastern & southeastern parts where it encounters at the depth varying from 207.00 to 231.00 mbgl. The sub-surface studies reveal that the sediments of the sandy facies (granular zones) in the western parts have predominance of gravels and rock particles of Quartzite sandstone and Limestone which may be due to the vicinity of their provenance area. The sediments of the sandy facies occurring at depths in the western parts of the area appear to be much mature type as these are comprising of sands of different grades associated with the occasional gravels. In these areas the rock particles of Quartzite and sandstone are mostly occurring in the weathered mantle at the top of the basement at deeper depths.

The clayey facies mainly contain the clay and silty sediments. Kankars are found associated with both the horizons generally in the sporadic manner.

The complex nature of sediments and quick alteration of clay and sand zones develop a multi layered aquifer system in the area.

IV. HYDROGEOLOGY

4.1 Delineation of Aquifers & their Characteristics :

The aquifers system of the study area is made up mainly of the alluvial sandy facies in the form of granular zones of sands, gravels and rock particles occasionally mixed with kankars. These aquifers have good permeability and transmissivity due to the interconnected pore spaces and interstices between the sand grains and gravels. The aquifers of the study area existing in between 21 meter to 220 mbgl have the transmissivity (T) varying from 25 to 1205 m^2/day. The storavity (S) values vary from 4.8×10E-6 to 8.5×10E-4. (Table-VI). The clayey facies, mainly constituted of clays occasionally mixed with silt and kankar, occur in the form of beds and lenses. These beds and lenses have very insignificant permeability and transmissivity values, hence act as the confining layers or hard-pans. These confining layers of the clayey facies and the granular zones of the sandy facies are more or less occurring in an alternating pattern, and hence provide a multi layered framework to the aquifer system. The upper most phreatic aquifer exhibits water table conditions, whereas comparatively deeper aquifers are semi-confined to confined type. The phreatic or water table aquifers are mainly recharged by rainfall, and seepage from surface water bodies viz. canals, lakes and ponds etc. The withdrawal of ground water from these aquifers is mainly made through the shallow tubewells of cavity/strainer type, borings, hand pumps and dug wells etc. The base flow of the perennial rivers/tributaries and the water requirements of the deep-rooted phreatophitic plants are also met by this upper most phreatic aquifer system. The unconfined aquifers are comparatively more sensitive to the seasonal and environmental changes. The deeper aquifers existing in between the prominent confining layers are under semi-confined to confined conditions, generally encountered below the depth of 50 mbgl. A perusal of sub-surface geological sections there is by and large, two tier Aquifer system of the semi-confined to confined aquifers occurring down to the depth of 231 mbgl.

In the marginal alluvial plains lying in the southwestern parts of the district under the Jagnair and Fatehpur Sikri blocks, only the upper tier of the semi-confined to confined aquifer system along with the upper most phreatic aquifer system exist where as the deeper second tier of the semi-confined to confined aquifer system is missing. In these two blocks, the ground water in the isolated hillocks, ridge and

Table-VI

HYDROGEOLOGICAL DATA OF THE EXPLORATORY TUBEWELLS CONSTRUCTED BY CGWB IN AGRA DISTRICT, U.P.

S. No.	Location/ latitude/ longitude/ Toposheet	Type of well	Drilled depth/ bedrock (mbgl)	Zone tapped (mbgl)	Water level (mbgl)	Yield (lpm)	Draw-down (m)	Transmi-ssivity (m^2/day)	Storativity (S)	Geology	Electrical conductivity (micromhos/ cm. at 25^0C)	Chloride (mg/l)	Remarks
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1.	Basai Kalan $27^0$09'00" $78^0$03'30" 541/4	EW	155.75	-	-	-	-	-	-	Alluvium	-	-	Abandoned, lack of granular zones
2.	Bharapur $27^0$02'20" $78^0$18'30" 541/8	EW	182.88	-	-	-	-	-	-	Alluvium	7898	1900	Abandoned due to salinity
3.	Daudpur $27^0$04'12" $77^0$31'36" 54E/12	EW	107.51 105.75 Lst	48-55 88-96	0.69	1500	-	860	$4.8\times10E-^6$	Alluvium	2565	504	-
4.	Fatehpur Sikri $27^0$04'46" $77^0$39'30"	EW	77.20	26-35 38-41	5.84	1236	-	1174	0.845×10^{-3}	Alluvium	2100	227	-
5.	Jagner $26^0$52'00" $77^0$35'30"	EW	64.00	36-54	4.53	708	16.43	270	-	Alluvium	1760	241	-
6.	Jaitpur Kalan-1 $27^0$49'45" $77^0$41'45"	PZ	207.97	82-90 106-109 127-133 145-151 169-175	-	-	-	-	-	Alluvium	-	-	-

S. No.	Location/ latitude/ longitude/ Toposheet	Type of well	Drilled depth/ bedrock (mbgl)	Zone tapped (mbgl)	Water level (mbgl)	Yield (lpm)	Draw-down (m)	Transmi-ssivity (m^2/day)	Storativity (S)	Geology	Electrical conductivity (micromhos/ cm. at 25^0C)	Chloride (mg/l)	Remarks
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
7.	Jaitpur Kalan-2 $27^0$49'45" $77^0$41'45"	PZ	70.00	22-25 37-49 57-63	-	-	-	-	-	Alluvium	-	-	-
8.	Jautana $27^0$05'06" $77^0$34'54" 54E/12	EW	77.10 76.7 Sst	-	-	-	-	-	-	Alluvium	-	-	Abandoned no granular zone & poor quality
9.	Kheragarh $26^0$58'00" $77^0$48'45"	EW	71.20 71.0 Sst	31-37 48-54 60-66	9.74	473	16.50	25	$1.8\times10E^{-4}$	Alluvium	4920	1489	-
10.	Mohrampur $26^0$58'38" $78^0$08'15"	SH	128.00	56-66 112-124	-	600	5.0	-	-	Alluvium	1550	199	-
11.	Nagladulekhan-1 $26^0$54'30" $77^0$43'00"	PZ	128.10	93-98	11.74	500	5.0	40	-	Alluvium	19000	5000	Brackish to saline quality
12.	Nagladulekhan-2 $26^0$54'30" $77^0$43'00"	PZ	45.00	19-24 36-39	-	-	-	-	-	Alluvium	-	-	Brackish to saline quality
13.	Pinhat-1	PZ	223.00	102-105 124-130 160-172 211-217	-	-	-	-	-	Alluvium	-	-	-
14.	Pinhat-2	PZ	62.00	40-58	-	-	-	-	-	Alluvium	-	-	-

S. No.	Location/ latitude/ longitude/ Toposheet	Type of well	Drilled depth/ bedrock (mbgl)	Zone tapped (mbgl)	Water level (mbgl)	Yield (lpm)	Draw-down (m)	Transmi-ssivity (m^2/day)	Storativity (S)	Geology	Electrical conductivity (micromhos/ cm. at 25^0C)	Chloride (mg/l)	Remarks
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
15.	Samra $27^0$05'33" $77^0$33'44" 54E/12	EW	108.78 107.51 Qtz	45-60 87-105	2.43	3406	-	1205	$4.7\times10E^{-5}$	Alluvium	2450	376	Flowing well
16.	Sarendi $77^0$41'15" $26^0$55'30"	EW	126.00	53-62 76-84 90-102 108-120	-	1200	-	-	-	Alluvium	2875	426	Abandoned, silty formation
17.	Shamsabad-1 $27^0$01'30" $78^0$07'30"	PZ	168.17	142-147 150-154	-	-	-	-	-	Alluvium	-	-	-
18.	Shamsabad-2 $27^0$01'30" $78^0$07'30"	PZ	110.00	48-60 68-74 97-106	-	-	-	-	-	Alluvium	-	-	-
19.	Sikrara $27^0$03'25" $78^0$14'35"	EW	183.49	63-71 99-106 117-127	12.50	1130	-	141	-	Alluvium	2517	265	-
20.	Singna $27^0$15'58" $77^0$49'40" 54E/15	EW	171.88 167.51 Lst	-	-	-	-	-	-	Alluvium	-	-	Abandoned lack of granular zones
21.	Sirauli $27^0$02'15" $78^0$34'30" 54E/12	EW	103.15 103.15 Sh	-	-	-	-	-	-	Alluvium	-	-	-

S. No.	Location/ latitude/ longitude/ Toposheet	Type of well	Drilled depth/ bedrock (mbgl)	Zone tapped (mbgl)	Water level (mbgl)	Yield (lpm)	Draw-down (m)	Transmi-ssivity (m^2/day)	Storativity (S)	Geology	Electrical conductivity (micromhos/ cm. at 25^0C)	Chloride (mg/l)	Remarks
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
22.	Kalindi Vihar $27^0$13'50" $78^0$03'20" 54I/4	EW	179.0 177.30 Sst	26-38	21.95	708	6.30	207	-	Alluvium	5050	880	-
23.	Rakabganj $27^0$09'50" $78^0$01'07" 54I/4	EW	140.0 140.0 Sst	21.5-24.5 26.5-32.5	13.93	800	7.81	164	-	Alluvium	6547	1489	-
24.	Patti Pachgai $27^0$07'30" $78^0$02'27" 54I/14	EW	150.75 Sst	68-80	13.12	250	24.45	42	-	Alluvium	1533	206	-
25.	Bhoor Ka Bagh $27^0$13'18" $78^0$01'30" 54I/4	EW	110.50	39-42 44-47 52-58	18.45	393	18.35	26.49	-	Alluvium	1843	330	-
26.	Tundla $27^0$12'33" $78^0$14'00" 54I/4	DW	231.12	20-30 167-170 204-220	10.54	1968	5.625	495	-	Alluvium	2015	369	-

platues of Vindhyan sand stones/quartzites, generally occur in the joint planes, fractures and rocky residual materials of weathered mantle, and have very feeble prospects of ground water development for major water requirements.

4.2 Depth to Water Level :

The depth to water level in the upper most phreatic aquifer system mainly depends on the general topography of the area, sub-surface geological configuration and constituents of granular zones, intensity of rainfall and influence of the surface water bodies. In accordance with these governing factors, the depth to water level in the area shows remarkable variation from west to east. A perusal of the depth to water level map for pre-monsoon period reveals that the entire area may broadly be classified into two zones viz. the western parts of area having comparatively shallow depth to water levels, and the eastern parts of area along Yamuna river with deeper depth to water level conditions.

As per the data of NHS during year 2012, depth to water level in phreatic aquifer varies from 2.19 to 45.58 mbgl during pre-monsoon period. In the western parts of area including Fatehpur Sikri, Achhnera and Jagnair. The water level rests at a depth ranging from generally 2.00 to 10.00 mbgl .The influence of canals has been observed in the canal command areas of Achhnera and Fatehpur Sikri blocks where the depth to water level is comparatively shallower which may be due to the sub-surface infiltration from canal. Such conditions are also prevailing in some pockets along canals.

The depth to water levels in hard rock terrain of Jagnair block generally range between 7 and 10 mbgl. In the eastern and southeastern parts of area specially in the vicinity of Yamuna river i.e. in Bichpuri, Shamsabad, Fatehabad, Pinhat, Bah, Jaitpur Kalan, Khadauli and Etmadpur blocks deeper depth to water level conditions exist and depth to water levels in these areas generally varies from >10 to >35 mbgl. The deepest depth to water level has been recorded in Yamuna-Chambal doab in the Shamsabad & Fatehabad areas. In the southeastern ravinous parts of the younger alluvium along Chambal river water levels generally rest at more than 30 meters depth range below ground level (Plate-I & II).

4.3 Water Level Fluctuation :

The water level data recorded from the National Hydrograph Stations (NHS) during the pre and post-monsoon period were analyzed and the seasonal water level fluctuation for the year 2012 have been taken into consideration. The seasonal fluctuation in water levels of the area is governed by the monsoon rainfall recharge, seepage from canals, return flow from applied irrigation and ground water development/draft.

The NHS data for the year 2012 shows that the water level fluctuation between pre and post-monsoon period varies in general from 0.28 to 7.75 meters Rise, and 0.14 to 0.76 m Fall. The seasonal rise in water levels are more prominent in the hard rock terrain of Jagnair block and also in Achhnera & Fatehpur Sikri blocks under canal commands. It has also been observed that a few pockets of area lying under Shamsabad, Fatehabad Bah, Jaitpur Kalan, Barauli Ahir and Khairagarh blocks show a decline in water levels during post-monsoon period, which may be due to ground water over draft or localized poor monsoon rainfall recharge.

4.4 Long-Term Water Level Trend :

In order to study the behaviour of ground water storage in space and time the available water level data of National Hydrograph Station located in Agra district, were analysed for the period 2003 to 2012 and based on these data long-term water level trend was worked out .

A study of these data reveals that out of total 09 Nos. of National Hydrograph Station 08 NHS are showing a declining trend of water table @ -0.0997 to –1.3367 m/year, and the remaining two are showing rising trend @ 0.3315 to 0.5753 m/year. The season wise analysis shows that durin **Pre-monsoon period** Fall is 0.1777 to 1.3403 m/year and Rise is 0.0140 to 0.7912 m / year, where as in **Post-monsoon** Fall is 0.0440 to 1.5872 m/year and Rise 0.2390 to 0.4595 m/year .

The National Hydrograph Stations located at Gangpur Basai and Shahganj Prithvinath under canal command area in the northwestern parts of the district are showing rising water level trends with space and time. However, in the major parts of the district, most of the National Hydrograph Stations are showing declining trend in water table with time, which may be due to the over exploitation of ground water resources. The declining trend in water level is so significant in the western parts of the district that most of the dug wells located in these parts have dried up.

V. HYDROCHEMISTRY

The quality of ground water and surface water resources has been assessed on the basis of chemical analysis results of water samples collected from the open wells, hand pump, shallow tubewells, deep exploratory tubewells and surface water bodies .

5.1 Ground Water Quality of Phreatic Aquifers :

Chemical properties, and the general ranges of concentration of different inorganic elements present in the ground water of the phreatic aquifers of the district analyzed during GW Management Studies , 1999-2000 and NHS samples 2011-12 are as follows :-

Table -VII

pH	:	7.24 to 8.98
E.C.	:	620 to 7700 microsiemens/cm. at 25^0C
Chloride	:	0.4 to 1988 mg/lit
Carbonate	:	Nil to 144 mg/lit
Bicarbonate	:	171 to 1385 mg/lit
Nitrate	:	0.9 to 101 mg/lit
Fluoride	:	Nil to 4.55 mg/lit
Calcium	:	8 to 292 mg/lit
Magnesium	:	12 to 362 mg/lit
Sodium	:	10 to 1380 mg/lit
Potassium	:	1.5 to 390 mg/lit
Total Hardness	:	120 to 2110 mg/lit
TDS	:	480 to 4698 mg/lit

5.1.1. pH Value :

It is the measure of alkalinity in the water as the alkalinity is usually associated with the high pH values. The ICMR (1975) has prescribed the permissible limit range of pH from 7.00 to 8.5, but allows a range of 6.5 to 9.2 for the domestic use. In general, the pH value in the ground water of the area varies from 7.24 to 8.98, indicating that the ground water in shallow aquifers is mildly alkaline in reaction, and well within the permissible limit for drinking purposes.

5.1.2 Specific Conductance (E.C.) :

The specific conductance or the Electric Conductivity (EC) is a measure of the Total Dissolved Solids (T.D.S.) in the water. On the basis of E.C., the quality of the ground water may be assessed for the domestic as well as irrigational uses. Whereas the suitability of water for irrigation purposes, has been assessed on the basis of Wilcox Classification. The Grond Water of Agra District is in general is of Permissible Class. However, at few places in Fatehpur Sikri, Achhnera, Fatehabad, Bichpuri, Agra city, Khandauli, Etmadpur, Jagner, Akola, and Khairagarh blocks the E.C. and T.D.S. values are higher.

5.1.3 Chloride :

The ICMR has proposed the desirable limit for chloride concentration in drinking water as 200 mg/l, however it allows concentration of chloride up to 1000 mg/lit in the absence of any other alternative source of water. The chloride concentration in excess of 100 mg/lit imparts salty taste. In general, the concentration of chloride ranges from 0.4 to 1988 mg/lit in the shallow ground water of the district. At few places in Bichpuri, Khandauli, Jagner, Akola, and Khairagarh blocks the concentration is higher.

5.1.4 Carbonates and Bicarbonates :

Concentration of carbonates in the ground water is almost nil except in few samples with traces. The bicarbonates associated with carbonate varies from 171 to 1385 mg./lit. The concentration of bicarbonates below 600 mg/lit is considered to be fairly safe and good for irrigation and domestic purpose. In the major part of the area the concentration of bicarbonates is well within the permissible limit, however, some areas are showing the concentration more than 600 mg/l viz. are mainly in Achhnera, Bichpuri, Etmadpur, Jagner, Akola, Bah, Barauli Ahir and Khairagarh blocks.

5.1.5 Calcium :

The presence of calcium contribute to the hardness of water. For drinking purpose the concentration of calcium up to 75 ppm is considered to be safe, although the maximum limit of concentration allowed by ICMR is 200 ppm. In general the calcium concentration in ground water of the study area range from 8 to 292 mg/lit, and it is well within the maximum limit in the major parts. At few places in Khandauli, Bichpuri, , Etmadpur, Jagner, and Akola blocks the values are higher.

5.1.6 Fluoride :

The desirable and maximum permissible limits of fluoride concentration in drinking water are 0.6 mg/l and 1.5 mg/l respectively (ICMR-1975). In most parts of the area, the concentration of fluoride ranges between 0.1 and 0.8 mg/l which is well within the maximum permissible limit of 1.5 mg/lit. However, the concentration of fluoride beyond the permissible limit have been recorded at few places in Bah , Shamsabad , Bichpuri , Fatehpur Sikari, Fatehabad, Jagner, Etmadpur, and Achnera blocks. The high concentration may cause fluorosis disease, if used for drinking purpose without proper treatment. It has been observed that in majority of cases, the concentration of fluoride in the ground water is below the minimum desirable limit of 0.6 mg/lit, which may cause dental-caries, if used for drinking purposes without taking proper remedial measures.

5.2 Ground Water Quality of the Semi-Confined to Confined Aquifers :

A perusal of the chemical analysis results of the ground water collected from the semi-confined and confined aquifer through Exploratory Tubewells show the following range of different chemical constituents.

Table-VIII

pH	:	6.5 to 8.6
E.C.	:	1533 to 19100 microsiemens/cm. at 25^0C
Chloride	:	199 to 5142 mg/lit
Bicarbonate	:	372 to 672 mg/lit
Sulphate	:	70 to 1872 mg/lit
Fluoride	:	0.5 to 2.27 mg/lit
Calcium	:	24 to 930 mg/lit
Magnesium	:	13 to 1556 mg/lit
Total Hardness as $CaCO_3$	:	115 to 3100 mg/lit
Sodium	:	239 to 2990 mg/lit
Potassium	:	2.4 to 12.0 mg/lit

The ground water collected from the Exploratory Tubewells and piezometers at Jautna, Sirauli, Bharapur, Khairagarh, Kalinali Vihar, Rakabganj and Nagla Dulekhan is brackish to Saline, having E.C. values beyond the permissible limit, and thus unsuitable for the drinking and irrigational purposes. The concentration of fluoride in major parts of the area ranges between 0.5 and 1.28 mg/l, however, in

water sample collected from a tubewell (40 m deep) at Rakabganj (Agra town) it has been recorded as 2.27 mg/l. the concentration of Nitrate, Chloride, Sulphate, Sodium etc are also very high at Rakabganj and indicated occurrence of highly polluted ground water in this locality.

5.3 Water Quality of the Surface Water Bodies :

The chemical analysis results of the water samples from the Yamuna, Utangon and Chambal rivers show that the concentrations of all the chemical constituents are well within permissible limits and the water is of good quality. The pH values of these surface water resources is greater than 7, hence the waters are basic in reaction. The E.C. values of the Utangon, Yamuna and Chambal rivers are 350, 990 and 463 microsiemens/cm. at 25^0C respectively, which area well within the permissible limit (ICMR-1975). The concentrations of Bicarbonates, chloride, Nitrate, Calcium, magnesium and sodium elements are comparatively higher in Yamuna river than the Utangon and Chambal rivers, but are well within the permissible limits. The concentration of fluoride is 0.2 mg/lit in Utangon river, 0.4 mg/lit in Chambal river, and Nil in the Yamuna river water. The river waters of Chambal and Utangon rivers are comparatively clear in appearance than the Yamuna river, which may be due to the comparative excess of sediments and organic constituents in the Yamuna.

VI. ESTIMATION OF GROUND WATER RESOURCE POTENTIAL AND DEVELOPMENT

The Agra district receives about 272593 ham. rain-water every year, which is the main source of ground water recharge. The quantum of recharge, by and large depends on the intensity of rainfall and surface water run off, nature of surface soil cover, land use, cropping pattern, and the vegetation cover etc. The other sources of ground water recharge are canal seepage, return seepages from irrigation, surface water bodies viz. Ponds, lakes & reservoirs etc. The block wise recharge of ground water through rainfall has been estimated by the methodology of GEC-1997.

A Rainfall Recharge Estimation by Water Table Fluctuation Method :

This method is based on the water balance approach, so it may also be referred as "Ground Water Balance Method". The block wise average water table fluctuation for the entire district has been calculated for the study year. The ground water recharge has been estimated taking into account the block wise specific yield. In these block wise recharge values, the values of monsoon ground water draft has been added, and the values of recharge by other sources during monsoon have been subtracted. Subsequently the block wise values of rainfall recharge has been normalized by taking into account the rainfall of the year and the Normal rainfall.

B Ground Water Recharge by Other Sources :

The recharge by other sources mainly includes canal seepages, return flow from surface and ground water irrigation and infiltration from lakes, ponds and surface reservoirs.

(a) Recharge from Irrigation Water applied by Surface Water Irrigation :

The recharge by surface water irrigation has been derived by taking into account the return flow factor of for monsoon crops (Kharif) and non-monsoon crops (Rabi). The quantity of irrigation water released in the distributary canal system has been taken from the irrigation department and ground water department U.P.

(b) Recharge from Irrigation Water Applied by Ground Water Irrigation :

The recharge from irrigation water applied by ground water irrigation is the sum of gross ground water draft during monsoon period and non-monsoon period.

(c) Recharge from Canal Seepage :

The estimation of recharge by the seepage from canal system has been computed by utilising the block wise lengths of main canal, branch canal, distributory and minor canal segments. The other factors utilised are wetted perimeter area, number of days the canal segment is in operation during monsoon & non-monsoon seasons, and the seepage factor of wetted area.

(d) Recharge from Lakes, Ponds and Tanks :

Blockwise recharge estimated under this head has been carried out by taking into account the total water spread area for the year under such structures, number of days water is available during monsoon & non-monsoon seasons, and the infiltration factor.

C Rainfall Recharge Estimation by Adhoc Norm or Rainfall Infiltration Factor (RIF) Method :

The rainfall recharge by this method has been estimated separately for monsoon non-monsoon seasons on the basis of block wise normal rainfall and rainfall infiltration factor.

D Determination of Annual Ground Water Recharge :

The rainfall recharge during monsoon season has been estimated block wise separately by water table fluctuation, and Rainfall Infiltration Factor (RIF) methods. The values arrived by both the methods have been compared block wise and then any one has been adopted on the Percentage of Difference (PD) criteria of 1997 norm. Whereas, the non-monsoon rainfall recharge values have been computed only by the Rainfall Infiltration Factor Method. Then the Total Annual Ground Water recharge for the entire district accounts for 110189.94 ham and the Net Annual Ground Water Availability is 99170.42 ham. (Plate-IV)

E Ground Water Draft :

The block wise estimation of ground water draft has been done on the basis of the actual number of different ground water exploitation structures & their unit draft values. . In the entire district, the estimated gross annual draft for irrigation is 88640.89 ham, and gross annual draft for Domestic & Industrial water supply is 6614.46 ham. Thus the existing gross GW annual draft for all uses accounts for 95255.35 ham., which is about 96% of the net annual ground water availability.

F Ground Water Development :

The block wise determination of the present level of ground water development has been done on the basis of the percentage ratio between the net annual availability of ground water and present gross annual ground water draft for all uses. Thus the present stage of ground water development is maximum (179.16%) in Akola, and minimum (36.95%) in Pinahat block .The six (06) blocks viz. Akola, Barauli Ahir, Bichpuri, Fatehpur Sikari, Khandauli, and Shamsabad have been categorized under Over Exploited.The only one block viz. Saiya has been determined as 'Critical', three blocks viz.Achhnera, Jagner, and Khairagarh are semi-critical, and remaining all 05 blocks are falling under 'Safe' category. Therefore there is a limited scope for the future ground water development in the entire study area. However, the poor quality of ground water in major parts of the district is big constraint and requires special attention in its development.

G Net Annual Ground Water Availability for all Future Uses :

This component for the study area has been estimated block wise on the basis of net annual availability and gross annual draft of ground water for all purposes. Thus the net annual ground water availability for future irrigation uses has been estimated 1969.65 ham. which is about 0 2% of the net annual availability of ground water. Table-IX

H Potential Recharge under Specific Conditions :

The potential recharge under specific conditions generally includes the extra ground water potential available under the water logged & shallow water table area, and the available potential of flood prone areas.

The extra ground water potential estimated in the water logged and shallow water table areas amounts for 57.38 ham. in the entire district. This extra ground water potential may be exploited during pre-monsoon season up to the limit when the water table decline will reach at the 5.00 m. below ground level. The emptied shallow water table aquifer will consequently get recouped in the coming season of monsoon.

I The Static Ground Water Resource Potential :

The static ground water resource potential existing in the unconfined Aquifer static part, semi-confined & confined aquifers upto 450 mbgl. or Bed rock of the district has been estimated. The estimated static ground water resource potential for the study area amounts to 236504.56 ham . which can be exploited in specific conditions very cautiously, so that the hydrogeological equilibrium may not suffer adversely.

J Future Prospects of Ground Water Development:

The net annual GW Availability of the Dynamic GW Resources for futer irrigational development in the district is 1969.65 ham which may be developed in stages. The State Tube Wells, Shallow/ other Tube Wells and Dug Wells with E/D pumps are main ground water extraction structures. The annual unit draft of State TW ranges from 7.01 to 18.40 ham, and the average of it is 11.11ham . Likewise the annual unit draft of Shallow/ other Tube Wells ranges from 1.21 to 1.63 ham and the average of it is 1.42 ham., and of Dug Well with E/D pump ranges from 1.26 to 1.66 ham (Average = 1.42 ham). About 90 % amount of the net annual GW availability (1773 ham) may be developed in different phases by these structures in futer fo irrigation. It is estimated that about 159 State Tube Wells , or 1239 Shallow/ other Tube Wells/Dug Wells with E/D pumps may be developed in futer for irrigation. As on STW may irrigate about 33 hat land , and a shallow TW/Dug Well with E/D pump about 4.3 hat land , an additional irrigational capacity to irrigate about 5300 hat land may be generated. This developmental plan may be done with caution after considering the local hydrogeological environment , so that it will be ecofriendly.

Table –IX

DYNAMIC GROUND WATER RESOURCES OF AGRA DISTRICT, U.P. (As on 31 March 2009)

(in ham)

Sl. No.	Blocks	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for Domestic & Industrial Water Supply	Existing Gross Ground Water Draft for All Uses (11+12)	Provision for Domestic and Industrial Requirement Supply for 2025	Net Ground Water Availability for future Irrigation development (10-11-14)	Stage of Ground Water Development (13/10)*100 (%)	Category (Safe /Semi - Critical /Critical / OE
1	*2*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
1	ACHHNERA	11108.99	7798.20	355.77	8153.97	629.48	2681.31	73.40	Semi Critical
2	AKOLA	5214.87	8979.00	363.71	9342.71	363.71	0.00	179.16	Over Exploited
3	BAH	5657.15	3133.54	488.38	3621.92	719.71	1803.90	64.02	Safe
4	BARAULI AHIR	6951.35	10873.09	326.99	11200.08	326.99	0.00	161.12	Over Exploited
5	BICHPURI	4740.06	5062.68	426.83	5489.51	426.83	0.00	115.81	Over Exploited
6	ETMADPUR	5414.99	4018.57	550.08	4568.65	550.40	846.02	84.37	Safe
7	FATEHABAD	6867.60	4704.89	622.16	5327.05	1374.80	787.91	77.57	Safe
8	FATEHPURSIKRI	9272.58	9960.47	542.09	10502.56	542.09	0.00	113.26	Over Exploited
9	JAGNER	4540.18	3602.39	388.60	3990.99	450.65	487.14	87.90	Semi Critical
10	JAITPURKALAN	6084.08	2074.23	351.67	2425.90	688.00	3321.85	39.87	Safe
11	KHANDAULI	4624.90	5029.45	441.07	5470.52	441.07	0.00	118.28	Over Exploited
12	KHERAGARH	8215.71	6306.36	306.21	6612.57	501.52	1407.83	80.49	Semi Critical
13	PINAHAT	6532.82	2118.03	295.80	2413.83	373.63	4041.16	36.95	Safe
14	SAIYAN	7170.50	6616.28	493.71	7109.99	509.61	44.61	99.16	Critical
15	SHAMSABAD	6774.64	8363.71	661.39	9025.10	661.39	0.00	133.22	Over Exploited
	TOTAL	**99170.42**	**88640.89**	**6614.46**	**95255.35**	**8559.88**	**1969.65**	**96.05**	-

VII. CONCLUSION AND RECOMMENDATIONS

The Agra district encompasses an area of 4027 Sq. Km. under Indo-Gangetic plain. The major part of it is underlain by the sediments of Quaternary age, only minor part lying in the western and southwestern parts of the district in Fatehpur Sikri, Achhnera and Jagner blocks is occupied by the Bhander sandstone of Vindhyans group. In general, the Quaternary alluvium is unconformably lying on the basement of Vindhyan Sand stones. The granular zones consisting of mainly alluvial sands of different grades and gravels form the 3-tier aquifer system in the area. These aquifer have good transmissivity of 25 to 1205 m^2/day and permeability (K) 17.25 to 18.22 m/day. The sub-surface prominent clay beds of insignificant permeability and transmissivity are acting as the confining layers, and provide a multi layered frame work to the aquifer system. The upper most tier of the aquifer group is under water table conditions and constitutes the phreatic aquifer system in the area, whereas the comparatively deeper aquifers are under semi-confined to confined conditions. Contrary to these, by and large, homogeneous types of alluvial aquifers, the southwestern hard rock terrains & valley fills have more or less heterogeneous type of aquifers, mainly in the form of joint plains, fracture zones and weathered rocky materials.

As per the data of NHS during year 2012, depth to water level in phreatic aquifer exact value varies from 2.19 to 45.58 mbgl during pre-monsoon period. and the water level fluctuation between pre and post-monsoon period varies in general from 0.00 to 7.75 meters Rise, and 0.00 to 0.33m Fall.. The depth to water level in the area lying in canal commands, have comparatively shallow depth to water levels, whereas the eastern and southeastern ravinous, parts of younger alluvium along Chambal river have the water levels at deeper depths. The long tem water level records of the National Hydrograph Stations (Dug wells) reveal that out of total 09 Nos. of National Hydrograph Station 08 are showing a declining trend of water table at the rate -0.0997 to –1.3367 m/year, and the remaining two are showing rising trend at the rate 0.3315 to 0.5753 m/yea. In general, the elevation of water table varies from 120 to 185 mAMSL and its master slope is by & large, from northwest to southeast with a gradient varying from 0.20 to 4.00 m/km. The general direction of ground water movement is following the master slope viz. northwest to southeast.

The major perennial rivers like Yamuna, Chambal, Utangon and Khari are of effluent type, thus gaining ground water from the phreatic aquifers.

The entire study area receives about 272593 ham rain water annually by the normal rainfall, out of which only 20.18% is recharging the phreatic aquifer system and creating about 55017 ham. ground water potential.

The net annual ground water availability in the entire district is 99170 ham., and the present annual ground water draft for all uses is 95255 ham. The level of ground water development of different blocks ranges from 37 to 179% and accordingly the six (06) blocks viz. Akola, Barauli Ahir, Bichpuri, Fatehpur Sikari, Khandauli, and Shamsabad have been categorized under Over Exploited. The only one block viz. Saiya has been determined as 'Critical', three blocks viz.Achhnera, Jagner, and Khairagarh are semi-critical, and remaining all 05 blocks are falling under 'Safe' category. However, the poor quality of ground water in major parts of the district is big constraint and requires special attention in its development.

The blocks identified as over exploited practically have no scope , 'critical' has very marginal scope for future development, whereas in the 'Semi-Critical' blocks the future ground water development may be exercised with full caution. Remaining blocks falling under 'Safe' category have good scope for future development. The net annual ground water availability for all future irrigation uses in the district is 1970 ham, and the available ground water potential under specific conditions amounts for 57 ham. which can be utilized for future ground water development with the aim to achieve the ultimate target of 200% cropping intensity, and coverage of the entire cultivable area under irrigated status.

On the basis of hydrogeological investigations and studies, the following recommendations are made for the future ground water development, utilization, and management.

1. The entire study area every year receives about 272593 ham. rainwater by the normal rainfall, out of which about 20 % only is recharging the sub-surface aquifers, and rest of 80 % mainly drained out as surface runoff by different rivers and suffers evaporation losses. This wastage of rain water in the form of surface run off and evaporation may be reduced by the normal methods of rainwater harvesting. In this direction 'Roof Top Rain Water Harvesting'

practices are more practicable specially in the metropolis and townships. By adopting such practices of water conservation, the decline in water table may be checked, and side by side the intensity of salinity in ground water may also be reduced to some extent. In this way we can improve the present percentage (20 %) of rainwater recharge component.

2. The brackish or saline ground water resources of the area may be utilized conjunctively with the fresh surface water resources available in Yamuna, Chambal, Utangon rivers, and existing canal network

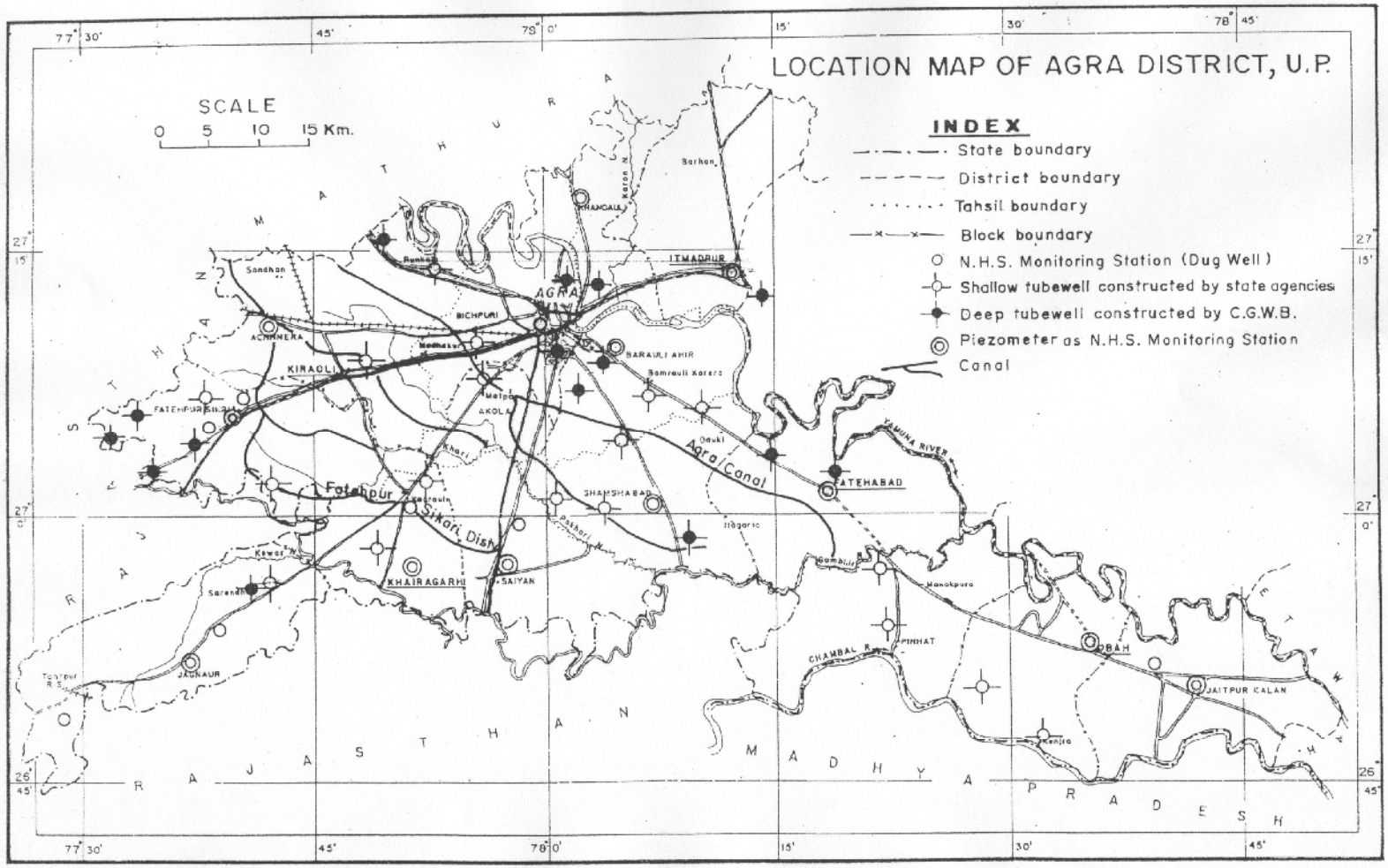
3. For tapping the fresh ground water aquifers, the borehole should be electrically logged before lowering the well assembly for the proper demarcation of sub-surface saline zones, and thereafter to seal up these zones by the cement to avoid the mixing of saline/brackish ground water in the tubewell with fresh water.

4. The district needs still more Ground Water Exploratory practices for evolving sub- surface Aquifer geometry more precisely, which may be achieved by Aquifer Mapping and Management Studies Program of CGWB.

5. Ground Water development in Over Exploited and Critical blocks of the district should be restricted , and if unavoidable, should be done with caution. Artificial Rainfall Recharge should be mandatory in such block.

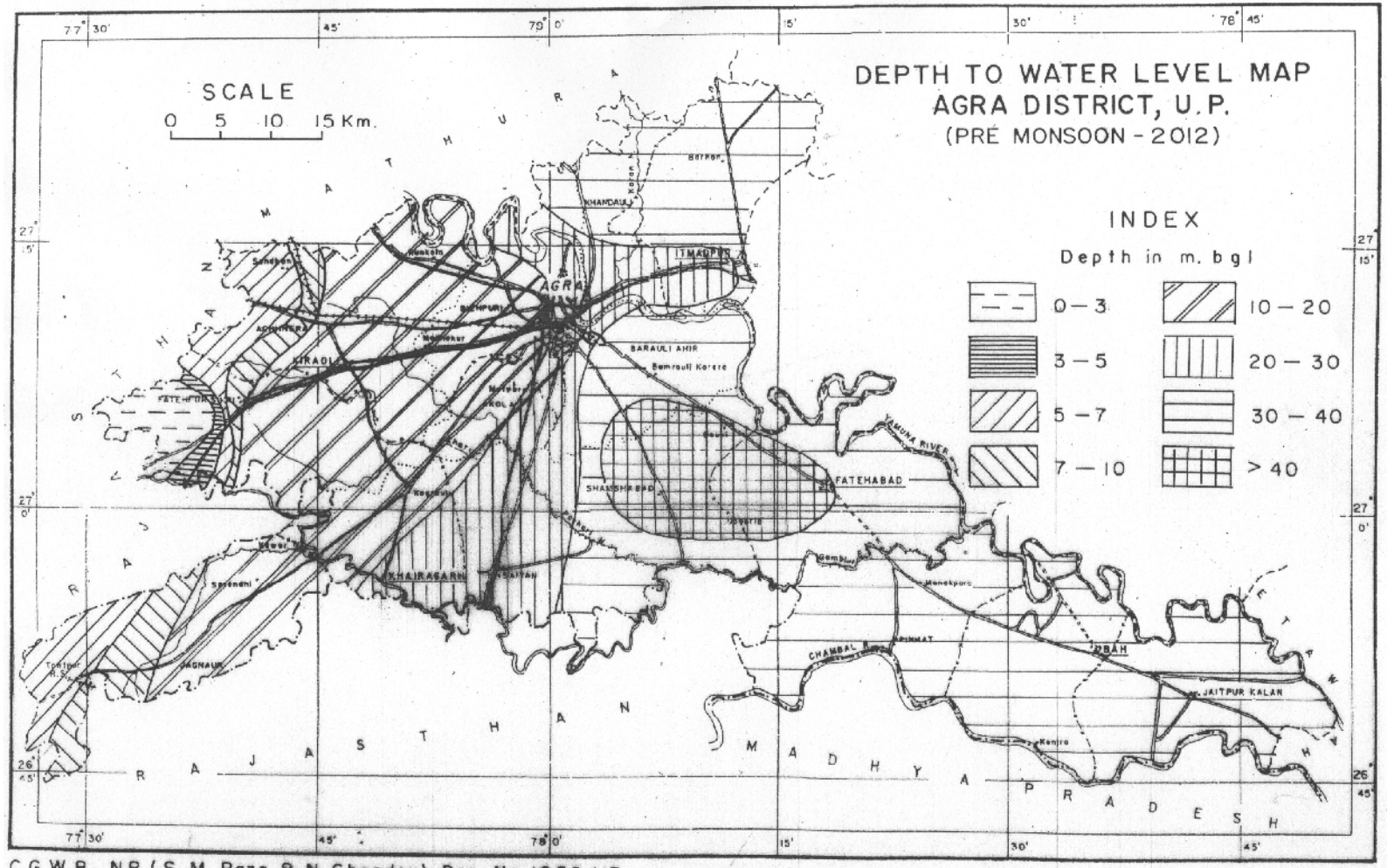
6. In the study area only 67% of the total gross sown area receive the assured irrigation facilities and the average cropping intensity is only 150%. With a view to increase the irrigation potential, and to achieve the ultimate target of 200% cropping intensity, the conjunctive use of ground water as well as surface water resources may be judiciously used.

PLATE-I



CGWB, NR (N. Chandra) Drg. No. 4908/13

PLATE - II



CGWB, NR (S. M. Raza & N. Chandra) Drg. No. 1909/13

PLATE-III

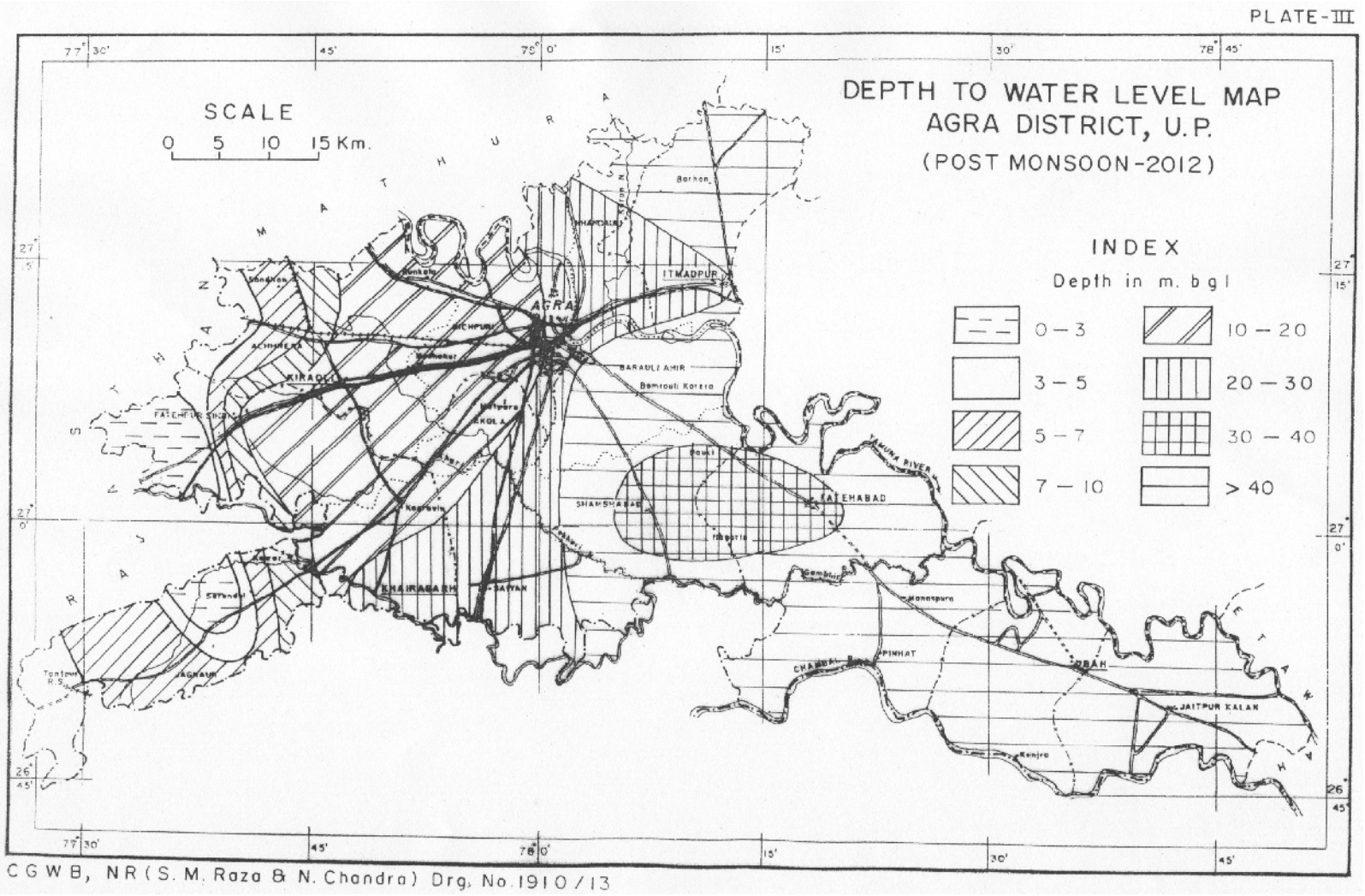


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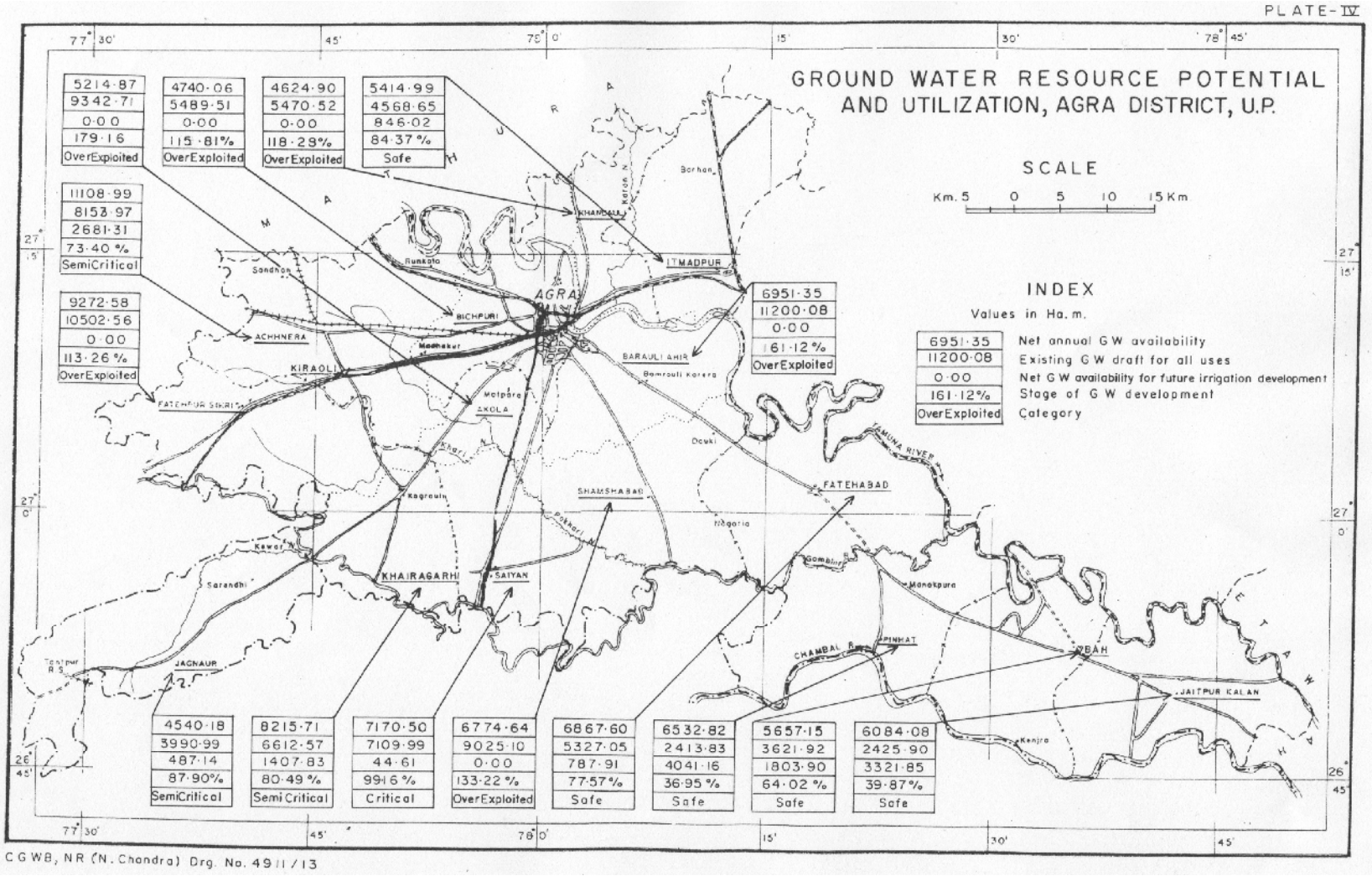
PLATE-IV



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