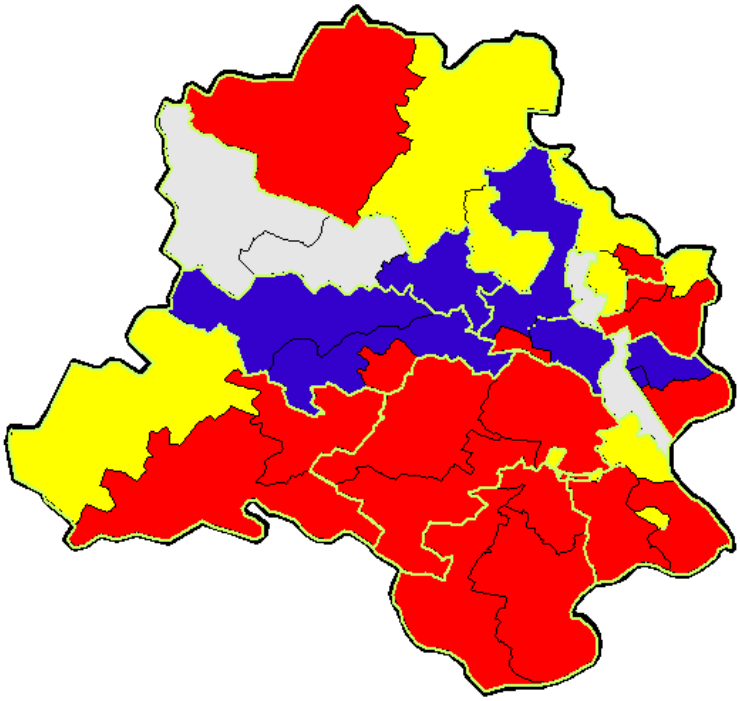
REPORT
DYNAMIC GROUND WATER RESOURCES OF NCT, Delhi As on March 2020



Central Ground Water Board
State Unit Office
New Delhi

Department of Water Resources, River Development & Ganga Rejuvenation
Ministry of Jal Shakti

March 2021

PRAVEEN GUPTA, I.A.S.
ADDITIONAL CHIEF SECRETARY

सत्यमेव जयते

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FOREWORD

Ground water is one of the most preferred sources of fresh water for various uses on account of its near universal availability, dependability and low capital cost. The groundwater is being extravagantly used in Delhi for various purposes including domestic, industrial and irrigation. The resultant scenario is the steady decline in ground water level in various parts of National Capital Territory of Delhi. Judicious management of resources requires its realistic assessment. In view of this, Central Ground Water Board, State Unit Office, Delhi takes up the task of estimating ground water resource of NCT Delhi at regular intervals. In this report, an attempt has been made to re-estimate the ground water resource potential of NCT Delhi and find out the status of ground water extraction taking into consideration the various usages of ground water in the capital city.

The re-estimation of ground water resources was carried out based on the latest methodology of estimation of groundwater resources popularly known as GEC2015 taking into account up-to-date data from various agencies involved in groundwater extraction and management in NCT of Delhi. The current status of ground water extraction is reflected in the category of various tehsils involving 33 (thirty-three) tehsils and 1(one) non-revenue unit "Nazul Land" as per existing administrative units. This report contains very useful data pertaining to ground water resources and its development in NCT, Delhi.

I appreciate the efforts of the officers of Central Ground Water Board, State Unit Office-Delhi led by its Officer In-charge Sh. Rana Chatterjee in bringing out this publication in such a short time which is quite tremendous task. I firmly believe that this report will be of significant use to all administrators, planners and other stake holders involved in formulation of strategies and interventions of ground water development and management in NCT Delhi.

1.12.2021

(Additional Chief Secretary)
Govt. of NCT Delhi

PREFACE

Ground Water has emerged as an important source of water in the NCT, Delhi. However, the uncontrolled use of ground water has resulted in depletion of water levels especially in areas underlain by hard rock. In order to precisely estimate the ground water resources available for various uses and judiciously plan the development of water supply programmes as well as to ensure food security, there is a need to assess the ground water resources periodically. In view of this, Central Ground Water Board takes up the task of estimating the dynamic ground water resources of NCT, Delhi based on GEC 2015 methodology after every two years.

The re-estimation of ground water resources as on 2020 has been carried out using the methodology recommended by Ground Water Estimation Committee (GEC'2015) and the updated data which were collected /provided from/by various State Government agencies. The present estimation has been done considering each Tehsil (Revenue Subdivision) as assessment unit to have more refined and accurate estimation. The current status of ground water development is reflected in the category of various Tehsils, which are assigned taking into consideration both the stage of ground water development and the trend of ground water levels. The report on "Dynamic Ground Water Resources of NCT, Delhi" contains very useful data pertaining to ground water resources and its development in the State. I sincerely hope this report will be of immense help not only to planners, administrators, researchers and policy makers but also to the common man in need of such information to make himself aware of the ground situation and help in formulating development and management strategy.

It is sincerely hoped that the present report will serve as useful tool for administrators, planners and government authorities in decision support and planning of ground water development schemes and management & regulation of this precious resource.

RANA CHATTERJEE
(OFFICER IN-CHARGE)
CGWB, SUO DELHI

DYNAMIC GROUND WATER RESOURCES OF NCT DELHI

AT A GLANCE

1.	Total Annual Ground Water Recharge	31811.76 (ham)
2.	Annual Extractable Ground Water Resources	28630.55 (ham)
3.	Annual Ground Water Extraction	29032.77 (ham)
4.	Stage of Ground Water Extraction	101%

CATEGORISATION OF ASSESSMENT UNITS (TEHSILS)

S. No.	Category	Assessment Units
1.	Safe	3 (9%)
2.	Semi Critical	7 (20.5%)
3.	Critical	7 (20.5%)
4.	Over Exploited	17 (50%)
	Total	**34 (100%)**

CONTRIBUTORS

Assessment of ground water resources of NCT Delhi is based on the hydrogeological data collected during the field investigations carried out by the scientists of Delhi State Unit Office, CGWB and extraction & artificial recharge data gathered from State Government Agencies. Main Contributors are – Directorate of Economics and Statistics, Govt. of NCT Delhi; Irrigation and Flood Control Department, Govt. of NCT Delhi; Delhi Jal Board; Census of India, 2011; Indian Meteorological Department; New Delhi Municipal Corporation; Delhi Cantonment Board; DMRC, Delhi Parks & Garden Societies; Delhi Pollution Control Committee. NWIC (National Water Informatics Centre, Ministry of Jal Shakti has also extended great help in spatial distribution of geo referenced extraction data. However, Indian Railways & CPWD has not provided any data and have been used in this report on pro rate basis.

The computation of the dynamic ground water resource of NCT Delhi and preparation of the report has been done by the team lead by Sh. Saidul Haq, Scientist-D in association with Sh. Faisal Abrar, AHG, Sh. S. Ashok Kumar, STA (HG) & Sh. V. Praveen Kumar STA (HG) under the active supervision and guidance of Sh. Rana Chatterjee, Officer In-charge, CGWB, SUO-Delhi.

This year CGWB is using online software IN-GRES to assess Dynamic Ground Water Resource as on 31 March 2020 using all input data of 2019.

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1. INTRODUCTION

Ground water Resources Estimation plays a pivotal role in effective implementation and monitoring of various guidelines issued by Govt. of India & State Governments. In view of the substantial changes observed in ground water resource scenario throughout the country, there is an emphasis has been laid in National Water Policy on periodic reassessment of ground water resources of the entire country for quantification, sustainable development and management.

The 'National Water Policy 2012 adopted by the Government of India regards water as a scarce natural resource, fundamental to life, livelihood, food security and sustainable development. It emphasizes that the efforts to develop, conserve, utilize and manage this resource must be guided by the national perspective. Correspondingly, safe water for drinking and sanitation is considered as pre-emptive needs, followed by high priority allocation for other basic domestic needs including needs of animals, achieving food security, supporting sustenance agriculture and minimum eco-system needs.

NCT Delhi being urban area wherein space for natural recharge is reducing abreast with infrastructural development both over the surface & under the surface posing challenges to planners and scientist to accurately assess Dynamic Ground Water Resource of NCT Delhi. The subsurface infrastructure developments (construction of double/triple basements, underground metro tunnel, Station, roads etc.) are also causing imbalance in natural sub surface flow of ground water.

1.1. Background of Ground water Resources Estimation

As early as in 1972, guidelines for an approximate evaluation of ground water potential were circulated by the Ministry of Agriculture, Government of India to all the State Governments and financial institutions. The guidelines recommended norms for ground water recharge from rainfall and from other sources. The first attempt to estimate the ground water resources on a scientific basis was made in 1979. A High-Level Committee, known as 'Ground water Over Exploitation Committee', was constituted by then Agriculture Refinance and Development Corporation (ARDC). This Committee recommended definite norms for ground water resources computations. In the year 1982, Government of India constituted "Ground water Estimation Committee" (GEC) with the members drawn from various organizations engaged in hydrogeological studies and ground water development. In 1984 this Committee, after reviewing the data collected by central and state agencies, research organizations, universities, etc., recommended the methods for ground recharge estimation. This is popularly known as GEC 1984. This was the first methodology which dealt with the subject exhaustively and assessed the resources on a fool proof method. This methodology was in practice for next 12 years. In the year 1996, Government of India again constituted "Ground water Estimation Committee" (GEC) with the members taken from various organizations engaged in hydrogeological studies and groundwater development. In 1997 this Committee, after reviewing the data collected by central and state agencies, research organizations, universities, etc. recommended the methods for ground water recharge estimation. This is popularly known as 'GEC 1997'.

Subsequently, GEC 1997 was revised and present methodology in vogue is 2015. GEC 2015 recommends aquifer wise Ground Water resource assessment to which demarcation of lateral as well as vertical extent and disposition of different aquifers is pre-requisite. Keeping in view of the rapid change in ground water extraction, GEC-2015 recommends resources estimation once in every three years.

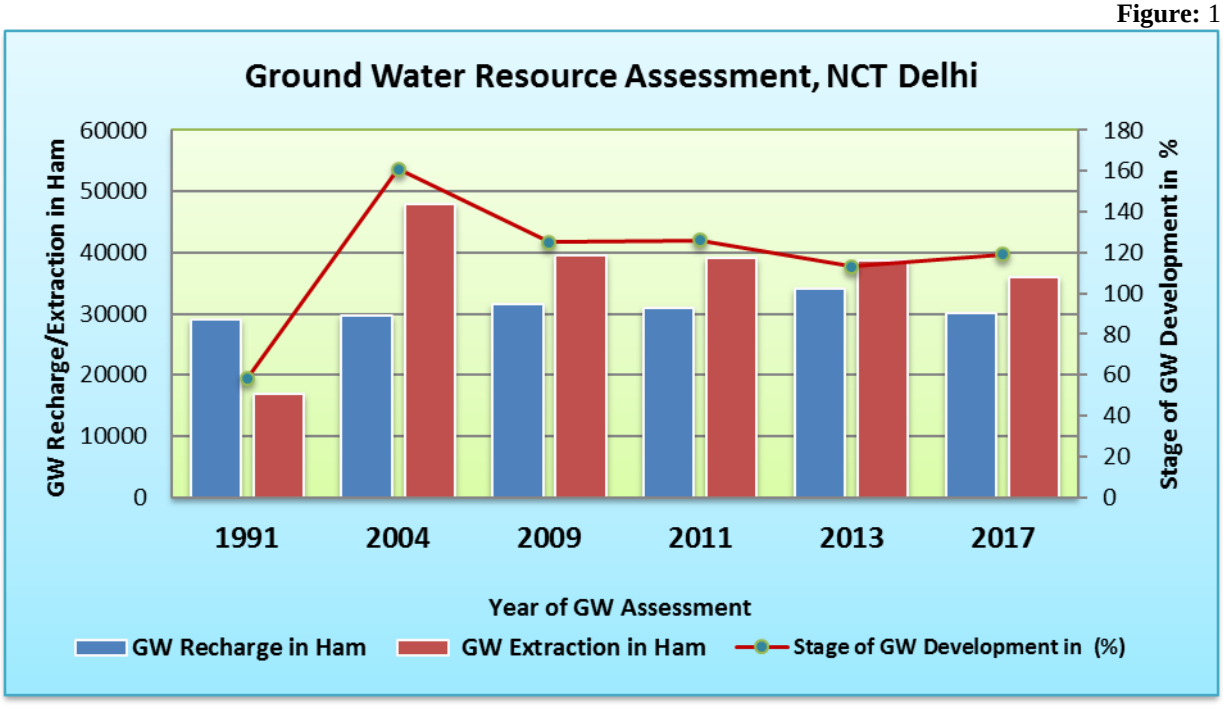
1.2. Previous Ground Water Resource Estimation of NCT Delhi

The Ground water Resources of NCT Delhi was estimated first time in year 1991 as per GEC 1984 methodology taking into consideration then 9 districts area as 'Assessment Unit' and then in year 2004 as per GEC 1997 methodology. Tehsil wise ground water resources estimation was undertaken during 2009, 2011 and 2013 for then 27 Tehsils of 9 district of NCT Delhi and for 34 tehsils of 11 districts and 1 non- revenue district during 2017. The summarized details of all such previous resource estimation of NCT Delhi is presented in Table 1 and depicted graphically in Figure 1.

Table 1: Previous Ground water Resource Estimation of NCT Delhi

Methodology	1991	2004	2009	2011	2013	2017
	GEC 1984	GEC 1997				GEC 2015
Total Annual Recharge (ham)	29154	29710	31501	31050	34192	30090
Total Ground water Extraction (ham)	16840	47945	39619	39215	38785	35990
Stage of Ground water Development (%)	58	161	125	126	113	119

Figure: 1



Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Govt. of India constituted a Central Level Expert Group (CLEG) for overall re assessment of ground water resources of the country as on 31st March 2010 vide Resolution dated 24th June 2020. Accordingly, a State Level 'State Ground Water Coordination Committee' (SGWCC) was constituted by the Government of NCT, Delhi vide order no. 16 (554)/UD/W/2015/Vol-I/1193-1211 dated 28th August 2020 for re-estimation of ground water resources as on March 2020 with 17 members under the Chairmanship of Principal Secretary, Urban Development, GNCTD. The list of members of the Committee constituted at the State level for re-estimation of ground water resources is given in the Table 2.

Table 2: Composition - State Ground water Coordination Committee, NCT Delhi

1	Pr. Secretary, Urban Development, GNCTD	CHAIRMAN
2	Commissioner, Deptt. of Industries, GNCTD	MEMBER
3	Chief Executive Officer, Delhi Cantonment Board	MEMBER
4	Member (Water Supply), Delhi Jal Board	MEMBER
5	Member (Engineering), Delhi Development Authority	MEMBER
6	Chief Engineer (Civil-I), NDMC	MEMBER
7	Chief Engineer, Zone-I, Irrigation & Flood Control Department, GNCTD	MEMBER
8	Chief Engineer, Zone-II, Irrigation & Flood Control Department, GNCTD	MEMBER
9	Chief Engineer, South Delhi Municipal Corporation	MEMBER
10	Chief Engineer, North Delhi Municipal Corporation	MEMBER
11	Chief Engineer, East Delhi Municipal Corporation	MEMBER
12	Director, Department of Environment, GNCTD	MEMBER
13	Joint Director (Agriculture), Development	MEMBER
14	General Manager, NABARD	MEMBER
15	Superintending Engineer (RWH), Delhi Jal Board	MEMBER
16	Garrison Engineer (Utility), Water Supply, MES	MEMBER
17	OIC, SUO, Central Ground Water Board	MEMBER SECRETARY

1.4. Brief outline of the meetings of the SGWCC, NCT Delhi

First meeting of the State Level Committee (SLC), NCT Delhi was held on 29th September 2020 under the Chairmanship of Principal Secretary, Urban Development, Govt. of NCT, Delhi. During the meeting CGWB gave background information on groundwater resource estimation and its importance and it was agreed that authenticated information about revised administrative units (33 tehsils/11 districts) in terms of its boundary, geographical area, population and related land use data may be obtained from concerned District Magistrate offices of NCT, Delhi. It was decided that Ground water Resource Estimation for the year 2020 would be taken up in these 33 Tehsils of 11 districts & one non-revenue unit (Nazul land) of NCT Delhi. Further, it was agreed that Ground water Resource Assessment 2020 would be taken up as per revised methodology of GEC, 2015. CGWB highlighted that the assessment of the Ground water Resources requires multiple data pertaining to groundwater Extraction & recharge from various department / agencies of GNCT Delhi. In this respect, numbers of departments /agencies of GNCT Delhi, namely DJB, NDMC, North, South & East MCD, DDA, DMRC, PWD, I&FC, Delhi Cantonment, Department of Industries etc were identified for providing the requisite input data.

Principal Secretary, Urban Development advised that all the concerned state govt. departments must co-operate to provide the necessary data to CGWB in the format provided by CGWB. The minutes of the first meeting are annexed at **Annexure (Ia)**.

Second meeting of the SGWCC was held on 15th December 2020 under the Chairmanship of Special Secretary, Urban Development, Govt. of NCT, Delhi. Brief account of status of data provided by various state departments to CGWB was deliberated. During the meeting, data gap pertaining to ground water Extraction and artificial recharge was presented by CGWB. It was also decided to include CPWD and Railway representative as co-opted member of SGWCC for provided Extraction and recharge data because NCT, Delhi have large area under control these two departments. Chairman of SGWCC again requested all departments to provided geo-reference data to CGWB before 15th January 2021 so that Ground Water Estimation process could be initiated and finalize the Ground water Resources report of NCT, Delhi as per the data/information provided to CGWB. The minutes of the 2nd meeting is annexed at **Annexure (Ib).**

Third meeting of the committee was held on 17th February 2021 to consider Extraction estimation of dynamic ground water resource as on March 2020 as main agenda point. Despite all efforts of CGWB, Extraction report could not be presented for consideration of committee because of final result of IN – GRES software which is presently being used by CGWB for GW estimation of 2020 was not matching with the ground condition. The minutes of the 3rd meeting is annexed at **Annexure (Ic)**.

Fourth & final meeting of SGWCC (State Level Groundwater Coordination Committee) held on 26th March 2021 for approval of dynamic ground water resource as on March 2020. CGWB, Delhi made a presentation regarding methodology adopted, processing of ground water extraction & recharge data and outcome of INGRES. Tehsil wise Category as Safe, Semi-critical, Critical and Over Exploited as on March 2020 was also presented. The Committee approved the Dynamic Ground Water Resource 2020 estimated by CGWB unanimously. The minutes of the 4th meeting is annexed at **Annexure (Id)**.

2. NCT DELHI: BACKGROUND INFORMATION

The National Capital Territory (NCT) of Delhi is spread in an area of 1483 Sq.km and lies between 28°24'15'' & 28°53'00'' *North Latitudes* and 76°50'24" & 77°20'30" *East Longitudes*, covered under Survey of India Toposheet Nos. 53D and 53H. It is surrounded on three sides by two States, i.e., on North, West and South by Haryana and in the East across the river Yamuna by Uttar Pradesh.

2.1. Administrative Setup of NCT Delhi

NCT Delhi is divided in 11 Revenue District and one non-revenue unit, Nazul Land along river Yamuna (Table 3 & Figure 2). Each district is headed by a Deputy Commissioner and assisted by Additional District Magistrate & Sub Divisional Magistrates. The District Administration in Delhi is the *de-facto* enforcement department for all kinds of Government policies and exercises supervisory powers over numerous other functionaries of the Government. As per District Census Hand Book, 11 districts of NCT of Delhi are further subdivided into 3 Tehsils for each district and there are total 33 Tehsils, with 112 villages, 110 Census Town and 3 Statutory Towns. Administrative map of NCT of Delhi is shown in Figure 2 and list of districts and its tehsils are presented in Table 3a.

Figure: 2

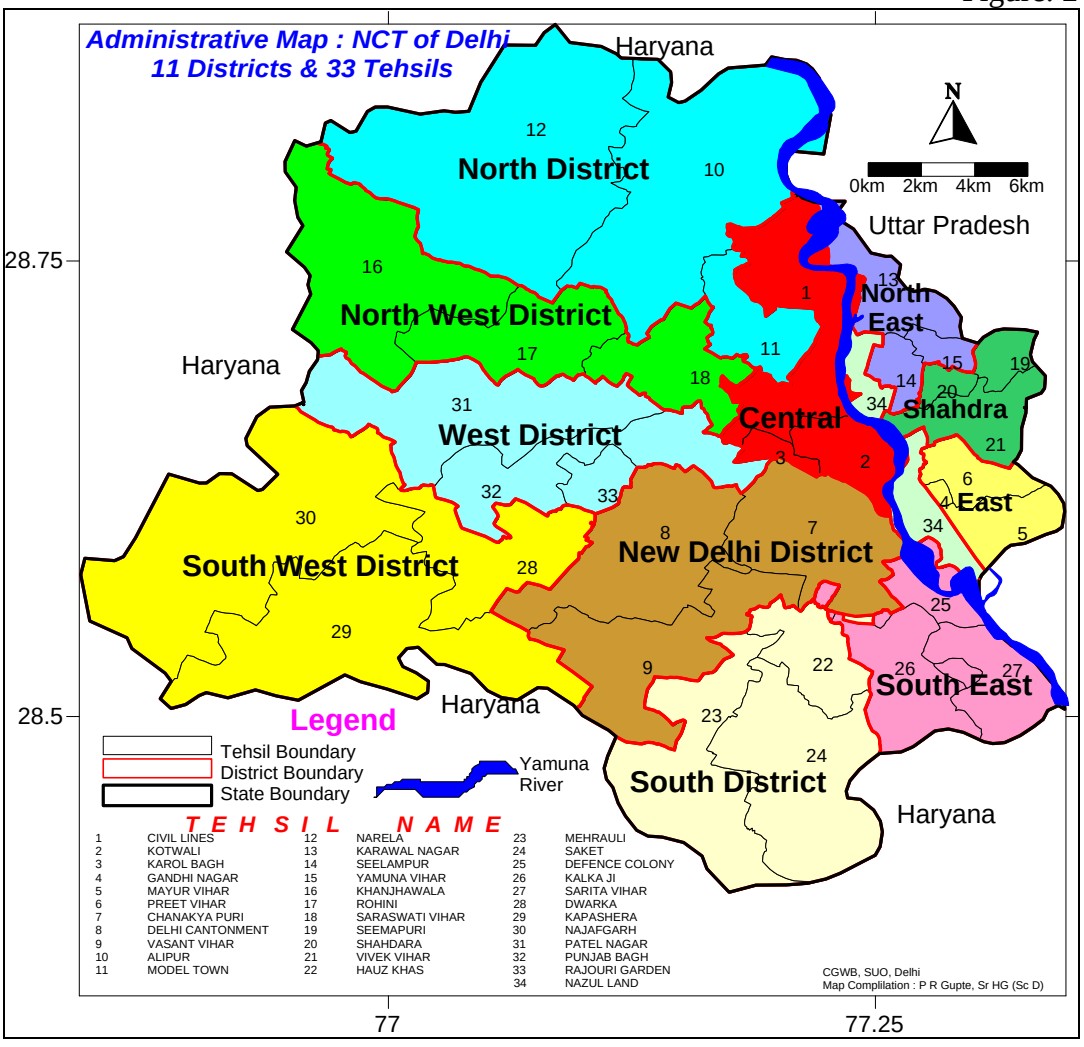


Table 3a: Details of Administrative Units - NCT of Delhi

Sr No.	District Name	Tehsil Name
1	CENTRAL	CIVIL LINES
		KOTWALI
		KAROL BAGH
2	EAST	GANDHI NAGAR
		MAYUR VIHAR
		PREET VIHAR
3	NEW DELHI	CHANAKYA PURI
		DELHI CANTONMENT
		VASANT VIHAR
4	NORTH	ALIPUR
		MODEL TOWN
		NARELA
5	NORTH EAST	KARAWAL NAGAR
		SEELAMPUR
		YAMUNA VIHAR
6	NORTH WEST	KHANJHAWALA
		ROHINI
		SARASWATI VIHAR
7	SHAHDARA	SEEMAPURI
		SHAHDARA
		VIVEK VIHAR
8	SOUTH	HAUZ KHAS
		MEHRAULI
		SAKET
9	SOUTH EAST	DEFENCE COLONY
		KALKA JI
		SARITA VIHAR
10	SOUTH WEST	DWARKA
		KAPASHERA
		NAJAFGARH
11	WEST	PATEL NAGAR
		PUNJAB BAGH
		RAJOURI GARDEN
Non-Revenue Unit Area		NAZUL LAND

2.2. Population & Land use

As per 2011 Census of India Report total population of NCT Delhi is 167,87,944 persons. Out of total 1483 Sq.km areas, only 25 % constitute rural areas spread in 112 villages, which is sparsely populated having population density of 1135 persons / Sq.km, whereas rest 75 % is urban areas spread in 110 Census Towns and 3 Statutory Towns and it is densely populated with population density of 14,698 persons / Sq.km. Details of villages & towns and its area & populations and land use pattern is given in table 3b & 3c respectively. Population of Delhi has increased at a rate of 2.1% per annum during the decade 2001-2011. Considering the same growth rate for the present decade, it is estimated that the population of Delhi in 2019 will be about 184 lakhs and it would be about 188 lakhs in 2021, 208 lakhs by 2031.

Table 3b: Area, Population & Details of Towns and Villages: NCT of Delhi

Area & Population	
Total Area: 1483 Sq.km	Total Population: 167,87,941 persons
Urban Area: 1114 Sq.km (75%)	Urban Population: 163,68,899 (98 %)
Rural Area: 369 Sq.km (25 %)	Rural Population: 4,19,042 (2 %)
Details of Towns - Urban Area	
Statutory Towns: 3	
New Delhi Municipal Council: Area 42.74 Sq.km;	Population: 2,57,803
Delhi Cantonment Board: Area 42.97 Sq.km;	Population: 1,10,351
Delhi Municipal Corporation: Trifurcated into	
North Delhi Municipal Corporation (NDMC)	
South Delhi Municipal Corporation (SDMC)	
East Delhi Municipal Corporation (EDMC)	
Census Towns: 110 - (List – Details Annexure I)	
DMC & Census Town Area: 1028 Sq.km	Population: 160,00,745
Details of Villages - Rural Area	
Villages: 112 List – Details Annexure I)	
Village Area: 363.35 Sq.km	Population: 4,19,042

Source: Delhi Statistical Handbook-2019: www.delhigovt.nic.in

Land utilization data for year 2018-19 reveals that out of 1474.8 sq.km areas accounted for Land Records in NCT of Delhi, more than 60 % area is not available for cultivation whereas only 192.25 sq.km is available for cultivation and nearly 435 sq. km is gross cropped / agriculture areas. Nearly 6 % of total area is under forest, cover mostly notified ridges and other forest pockets under DDA & government forest land. Break up of land utilization is presented in Table 3b&3c and depicted graphically in Figure 3.

Table: 3c Utilization of Land in Delhi (2018-19) Area in Hectares

Area according to Land use Records (Exclude Forest)		147488
Area not Available for Cultivation		92700
(a) Land Put to Non-Agriculture Use -	76218	
(b) Barren and Uncultivated Land	16482	
Other Uncultivated Land		11124
(a) Permanent Pasture & Other Grazing Land	61	
(b) Land Use Under Miscellaneous Uses	1170	
(c) Cultivable Waste Land	9893	
Fallow Land		19225
Net Area Sown		22300
Area Sown more than once		11155
Total Cropped Area		33455
Area Under Forest		9453
(a) Forest Under DDA	1281	
(b) Notified Ridge Forest	7784	
(c) Other Forest Area	388	

Source: Joint Director of Agriculture, Govt of NCT Delhi

Table: 4 Sources of Irrigation and Irrigated Area 2018-19

Source		Area Irrigated (in Hectare)	
Canals			2236
Tanks			0
Wells	TWs	18647	19635
	Others	988	
Net Area Irrigated			21871
Area Irrigated More Than Once			7762
Gross Area Irrigated			29633

Source: Joint Director of Agriculture, Govt of NCT of Delhi

Main source for irrigation in NCT of Delhi is groundwater whereas surface water is also available from Trans Yamuna Canal Network. Details about sources of irrigation and areas under irrigation is presented in Table 4 and Figure 4.

Figure: 3

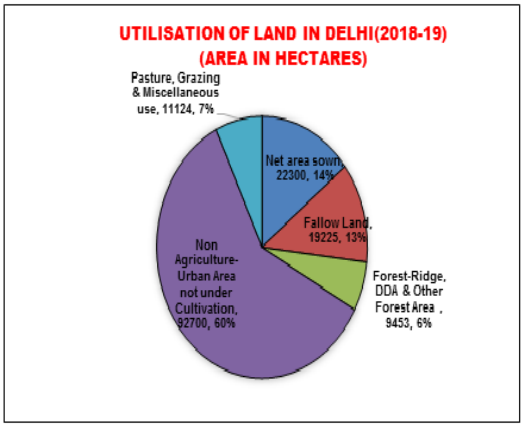
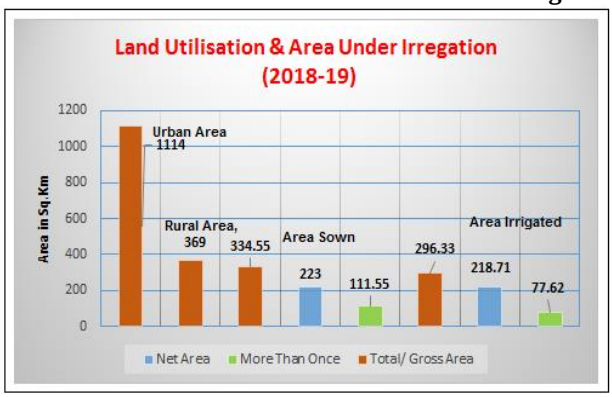


Figure: 4



2.3. Hydrometeorology

2.3.1. Climate

The climate of NCT Delhi is mainly influenced by its inland position and the prevalence of air of the continental type during the major part of the year. Extreme dryness with the intensely hot summer and cold winter are the characteristics of the climate. Only during the monsoon seasons does air of oceanic origin penetrate to this state and causes increased humidity, cloudiness and precipitation. The year can broadly be divided into three seasons (Table 5a). Data on long-term average climatologic parameters (IMD) covering monthly maximum / minimum temperature, relative humidity, evaporation and rainfall for NCT of Delhi is given in table 5b and presented graphically in figure 5.

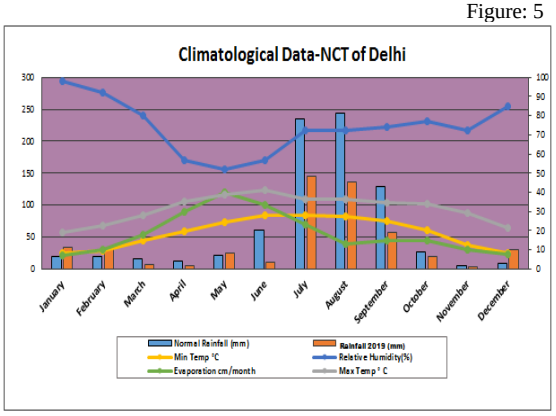
Table 5a: Climate Seasons in NCT Delhi

Season	Begin	End
Cold/Winter	End of November	Middle of March
Summer	Middle/End of March	End of June
Rainy season	Early July	September

Table 5b: Climatological Parameters of NCT Delhi

Month	Max Temp (°C)	Mini Temp (°C)	Relative Humidity (%)	Rainfall (mm) Normal	Rainfall (mm) 2019	Rainy Days	Eto (mm/d)
January	18.8	8.2	98	19.9	34.1	4	7.1
February	22.5	9.7	92	18.6	29.67	0	10.1
March	28.1	15.1	80	15.5	7.27	6	17.7
April	34.9	19.9	57	12.7	5.24	2	30
May	38.6	24.3	52	20.8	25.28	0	40
June	41.3	28.1	57	59.9	9.72	4	33.3
July	36.5	27.7	72	234.7	144.57	10	23.3
August	36.3	27.1	72	244.2	135.47	9	13.3
September	34.8	25	74	128.3	56.31	1	14.7
October	33.7	20	77	25.9	20.13	0	14.9
November	29	12.2	72	5.3	2.35	0	10.2
December	21.6	8.1	85	8.2	29.33	0	7.8
Total	-	-	-	**794**	**499.44**	**36**	**222.4**
Average	**31.3**	**18.8**	**74**				

Figure: 5



2.3.2. Rainfall

For ground water resource estimation 2020, average annual rainfall in NCT Delhi as per IMD records from 2015 to 2019 are taken into consideration. (Table5c).

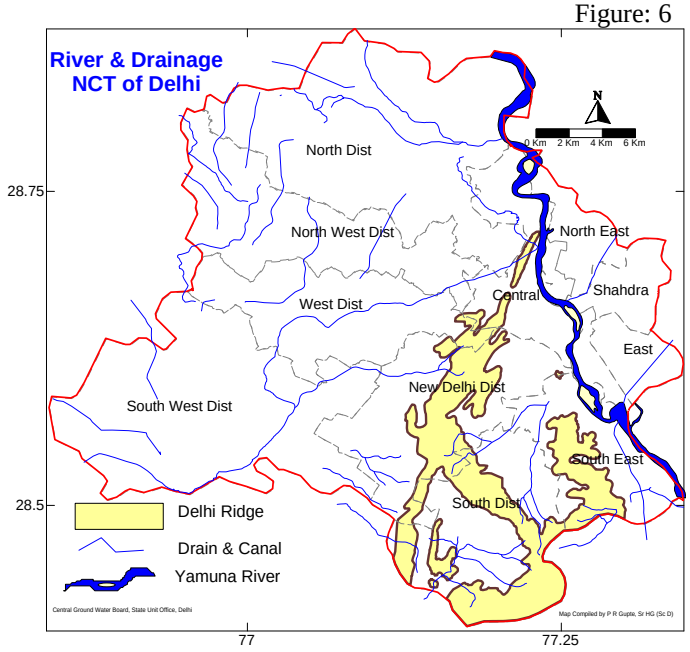
Table: 5c IMD Normal & Annual Rainfall, NCT Delhi

Year	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Annual
2015	19.5	138	598.5	1.7	757.7
2016	1.1	40.5	522.8	3.5	567.9
2017	38.8	47.5	442.6	4.8	533.7
2018	4.8	30.8	639.5	4.3	679.4
2019	57.9	26.5	380.6	40.6	505.6

2.4. Physiography & Drainage

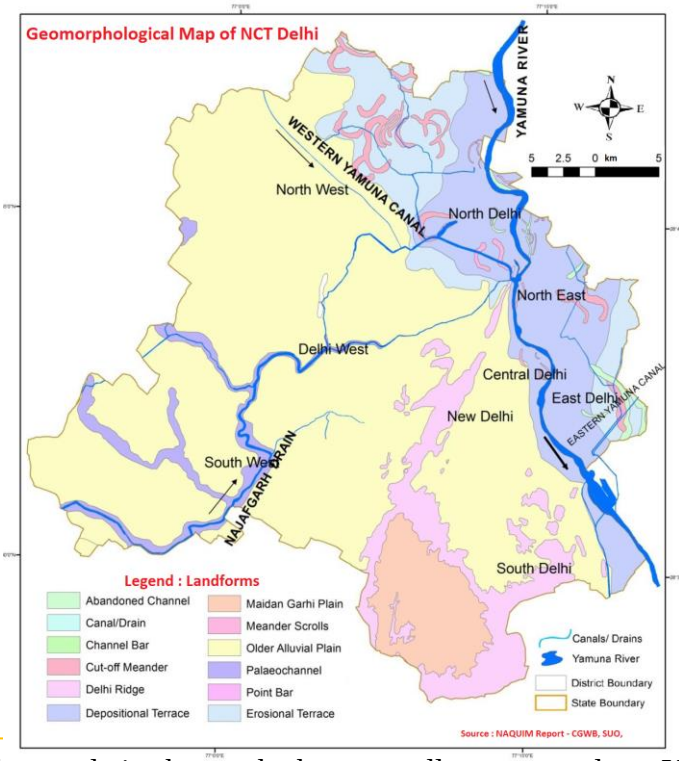
Physiography of Delhi is dominated by the Yamuna River, the Aravalli Ridges and the Alluvial Plains formed by alluvium deposits of Quaternary and Recent age. The SSW- NNE trending Aravalli rocks, designated as *Delhi Ridge*, occupy the south-central part of Delhi and extend up to western bank of Yamuna River near Okhla in the south and Wazirabad in the north-east. The Ridge rocks acts as a main water divide and are covered with forests. They are main recharge zones of NCT Delhi. The Yamuna river flowing in a southerly direction in the eastern part of the NCT of Delhi is the only perennial river. Other micro drainages, on the east of the ridge, enters river Yamuna, whereas on the West, it debouches into natural depressions in parts of South-West district. Main rivers & drainages of NCT Delhi are shown in map, Figure 6.

Figure: 6



2.5. Geomorphology

Figure: 7



The ground water availability in NCT of Delhi is indirectly relate with its distinct landform units, which in turn represent underlying intrinsic geological features. Map showing these landforms of NCT of Delhi are presented in Figure 7. All these landforms of NCT, Delhi can be grouped into three broad geomorphic units: namely Rocky surface, Older Alluvial Plain and Flood Plain of Yamuna River.

The rocky surface represents structurally controlled relict linear ridges and isolated hillocks comprising of rocks of Delhi Supergroup. This distinct landform comprising of isolated hills is most prominent in the south- and south-central parts and extends in the north shows small exposure along Yamuna River. The gently undulatory terrain on either side of the rocky surface is described as Older Alluvial Plain. Depending upon the morphological expressions / features, this unit is further divided into different

subunits: (i) Najafgarh Older Alluvial Plain, (ii) Delhi Older Alluvial Plain and (iii) Maidan Garhi Plain, which is a relatively higher plain surface and forms part of Chhatarpur Basin. A narrow zone of badland has formed mostly along the western margins of structural ridges due to intense development of gullies and rills.

The low-lying flat surface representing the Flood Plain of river Yamuna occupying northern, northeastern and eastern parts of the NCT is an important geomorphic unit. It represents the wide belt bounded on both the sides by Eastern and Western bunds and is naturally prone to annual / periodic floods being in the flood way and flood fringe zone of river Yamuna. This belt has very good potential for ground water development.

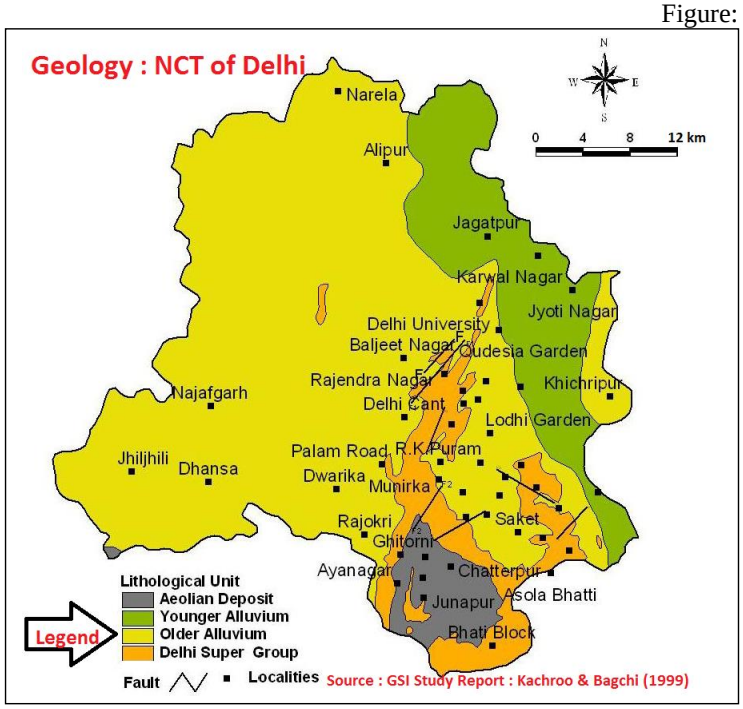
2.6. Geology

The rock formations exposed along the ridges of NCT Delhi, extending from Harchandpur (Haryana) in the South to Wazirabad (Delhi) in the North in NCT Delhi are mainly quartzite interbedded with thin bands of micaceous schist of Proterozoic age. Quaternary sediments, termed as alluvium deposit directly overlie the Proterozoic rocks. The geological map of Delhi showing these main units is shown in Figure 8 and generalized stratigraphy of NCT of Delhi is presented in Table 6.

Table 6: Generalized Stratigraphy, NCT Delhi

Alluvium	Newer Alluvium	Unconsolidated, inter-bedded lenses of sand, silt gravel and clay confined to narrow flood plains of Yamuna river and Aeolian deposit of South Delhi.
	Older Alluvium	Unconsolidated thickness varies upto 300m. Interbedded, inter-fingering deposits of sand, clay and kankar, poor to moderately sorted.
Delhi Super Group	Alwar Quartzite	Well stratified, thick bedded, brown to buff colour, hard and compact, intruded locally by pegmatite and quartz veins interbedded with mica schist.

Figure: 8



2.7. Hydrogeology: Aquifer System

In NCT Delhi region, exposures of the oldest litho-stratigraphic unit, the Delhi Quartzite ridge acts as main recharge zone to subsurface aquifer system. The Quaternary deposits in the form of aeolian and alluvial deposits are the major repository of ground water in the area. These two main hydrogeological units constitute main aquifer system for NCT Delhi.

2.7.1. Alluvium Aquifer

In the East of the ridge, the thickness of unconsolidated sediments gradually increases away from the ridge, with the maximum thickness being 170 m^1. In the Southwestern, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 297 m below land surface. In Chhattarpur basin, the maximum thickness of sediments is 116 m. The aeolian deposits of South Delhi mainly comprise silty and sandy loam. The bedrock is overlain by these deposits. Older alluvial deposits of west & northwest of NCT Delhi consist mostly of interbedded, lenticular and inter fingering deposits of clay, silt, and sand along with kankar. These deposits are overlain by the newer alluvium towards east, which occurs mostly in the flood plains of river Yamuna. All these alluvium deposits (soft rock formation) represent unconfined aquifers system of NCT Delhi.

2.7.2. Hard Rock Aquifer

The suits of quartzite and associated mica schist /phyllite bands of Delhi Group have undergone multiple folding and different phases of metamorphism in geological past. Natural weathering of quartzite in the semi-arid conditions around Delhi has made the Delhi Quartzite porous and subsequent friable and has given rise to features like tors, spheroids, gullies, cavities and small-scale caves on these quartzites terrain. However, its overall potential for ground water resources is poor compared to alluvium aquifer due to its intrinsic nature of having fractures / joints of secondary porosity. As such, the ground water occurs in unconfined condition, mainly in weathered portion and in fracture / joints at depth.

2.7.3. Subsurface Aquifer Dispositions

In recent study of CGWB taken up under NAQUIM, the detailed aquifer geometry on regional scale has been established in the NCT, Delhi (Figure 9). All available information about subsurface aquifer configuration, deciphered on basis lithological and geophysical logs of exploratory wells drilled by Central Ground Water Board under the Ground Water Exploration Program along with interpreted records of various geophysical studies etc., are integrated to prepare the aquifer map. From the geological sections and fence diagrams prepared, principal aquifers in the area have been delineated by grouping the fine, medium, coarse sand and sand with gravels as sand. Similarly, the top soil and silty clay or silt at the surface have been grouped together. Weathered and fractured quartzite and the massive quartzite/ bedrock have been grouped together as ‘Weathered / Fractured Quartzite’.

2.7.4. Fresh –Saline Ground Water Interface

Various hydrogeological and ground water exploration studies in NCT of Delhi by CGWB reveal that the thickness of fresh water in major part of NCT Delhi varies from 20 to 40 m. In NAQUIM projects, the granular zones (the aquifers) with varied resistivity were picked up from the combined interpretations of electrical resistivity (64 inches Normal) and gamma

logs of the boreholes drilled in the area. It is found that fresh water sediments are followed by the saline water sediments in all over NCT Delhi. The thickness of fresh water sediments is thin in major parts of NCT Delhi. The depth to fresh – saline water interface varies from 10 m bgl to 80 m bgl. In area underlain by alluvium deposits, the ground water quality below fresh saline water interface is saline all through up to the bedrock. At a few locations like Dhansa, Qutabgarh and Bankner, saline ground water is present at a very shallow depth range. A map showing thickness of fresh – saline ground water zones in subsurface aquifer system of NCT of Delhi, from groundwater modeling studies of NAQUIM project of CGWB is presented in Figure 10.

Figure: 9

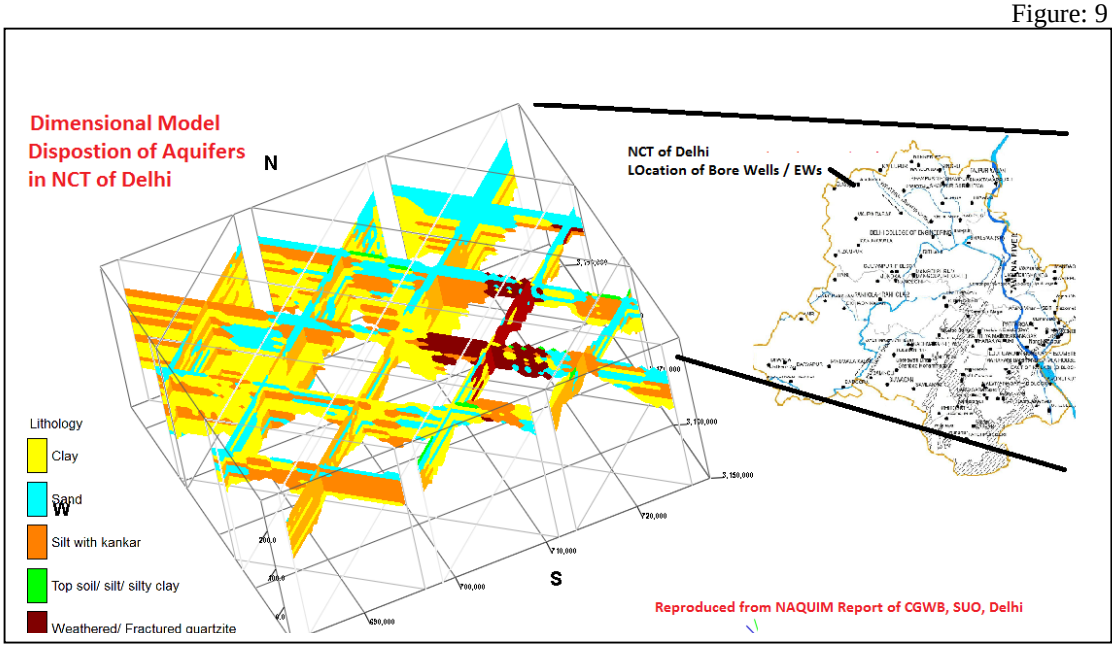
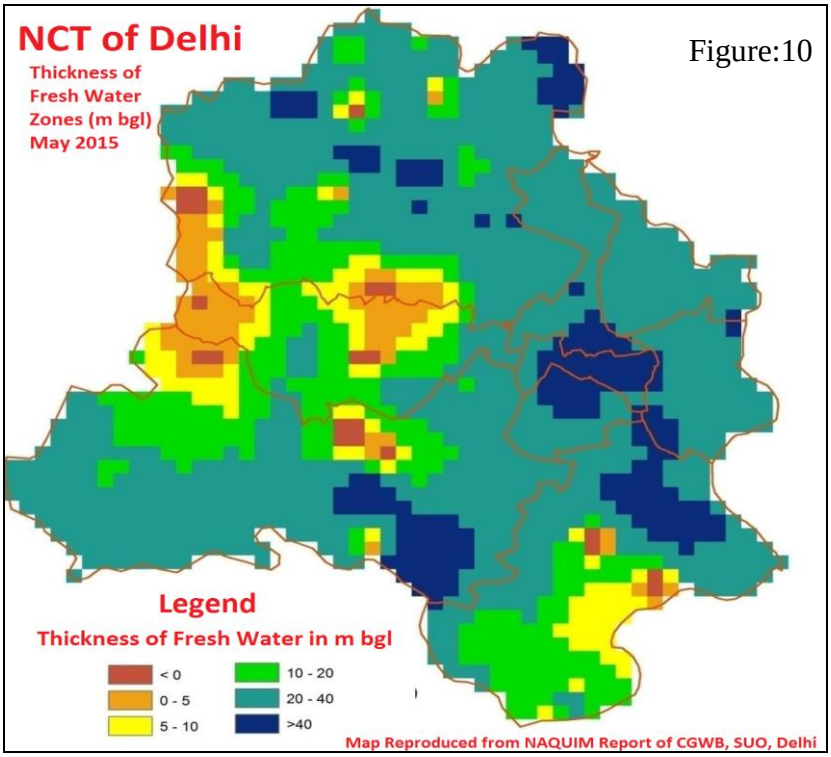


Figure:10



2.7.5. Basement Topography

The configuration of the basement rock topography, below variable thickness of alluvium of NCT of Delhi, worked out based on subsurface geological data generated from exploratory drilling and supplementary geophysical data input revels its uneven basement topography in NCT Delhi area (Figure 11).

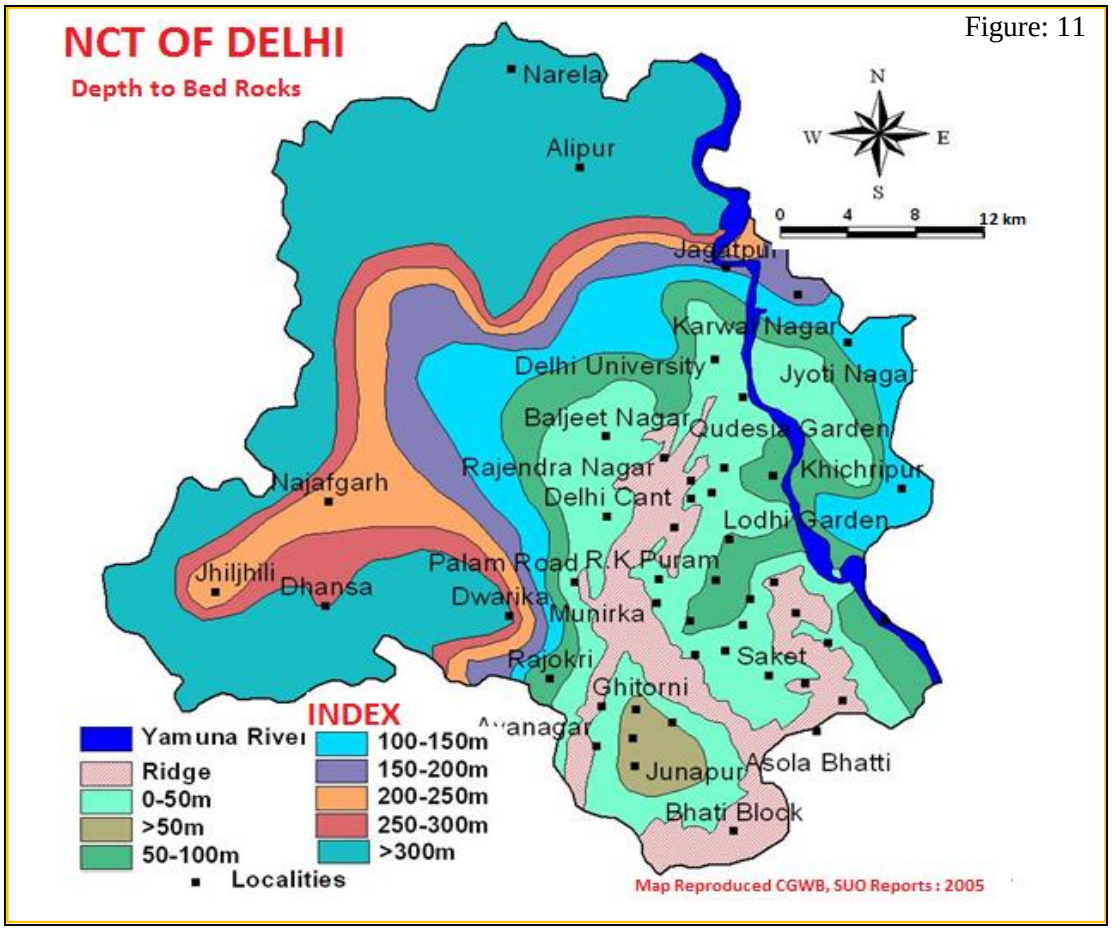


Figure: 11

3. GROUND WATER LEVEL IN NCT DELHI

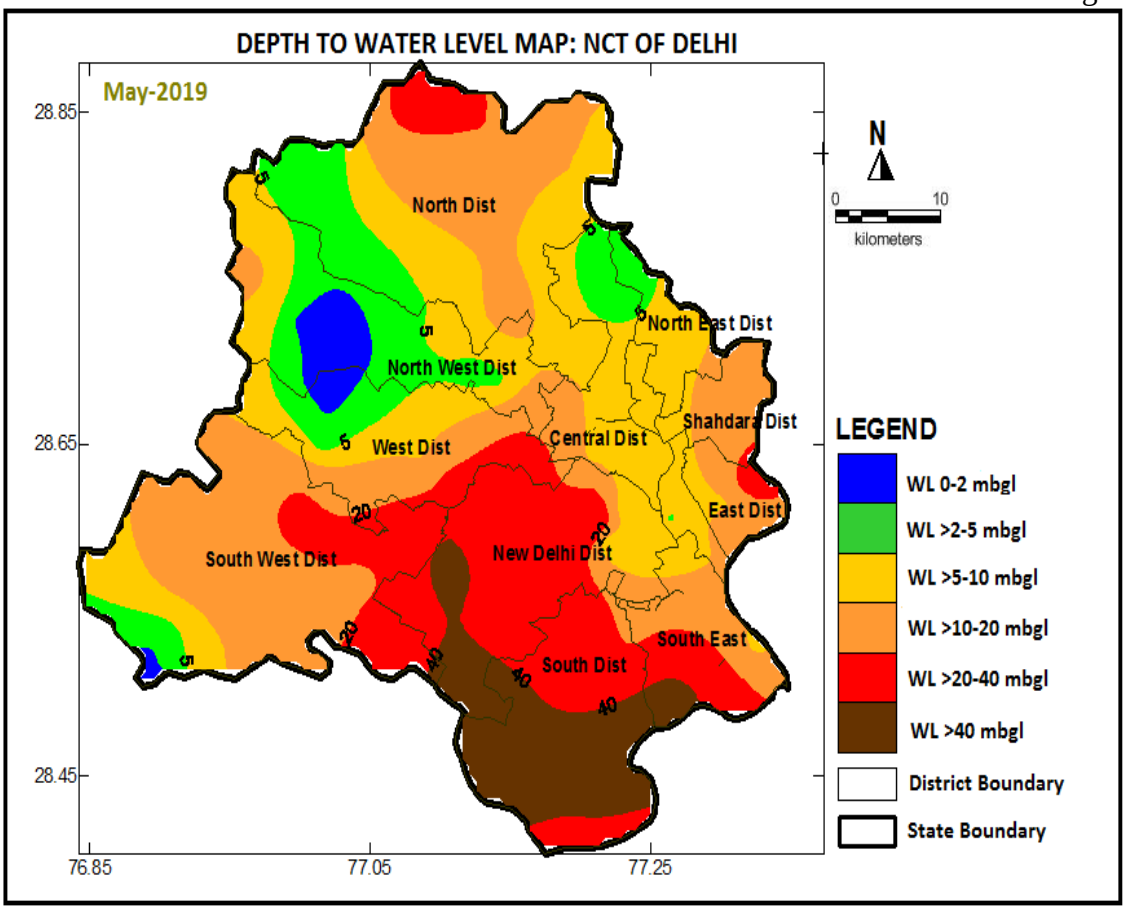
CGWB monitors ground water level in NCT Delhi four times in a year, during May 20th to 30th (water level of pre-monsoon period), August 20th to 30th (peak monsoon water level), November 1st to 10th (water levels of post-monsoon period) and subsequent year January 1st to 10th (the recession stage of water level). Ground water monitoring data of pre-monsoon (May) and post-monsoon (November) for last 10 year (2010-2019) have been considered for present GWRE 2020. Year wise water level data of each monitoring station **(Annexure IIa)** and decadal average **(Annexure IIb)** are presented as supplementary data of this report separately.

Water level monitoring data of NCT Delhi and its analysis, taken into consideration for GWRE 2020, is discussed as follows.

3.1. Pre-monsoon Water level – May 2019

The Pre-monsoon water level is measured in the month of May 2019 (Figure 12). The Depth to water level recorded in NCT Delhi during May-2019 ranges from 1.07 at Deorala to 62.64 mbgl at Gadaipur. About 4% of NCT Delhi areas, in parts of North, North West, South West, North East & Central districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 30% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 56% areas have water level in range of 5 to 20 mbgl.

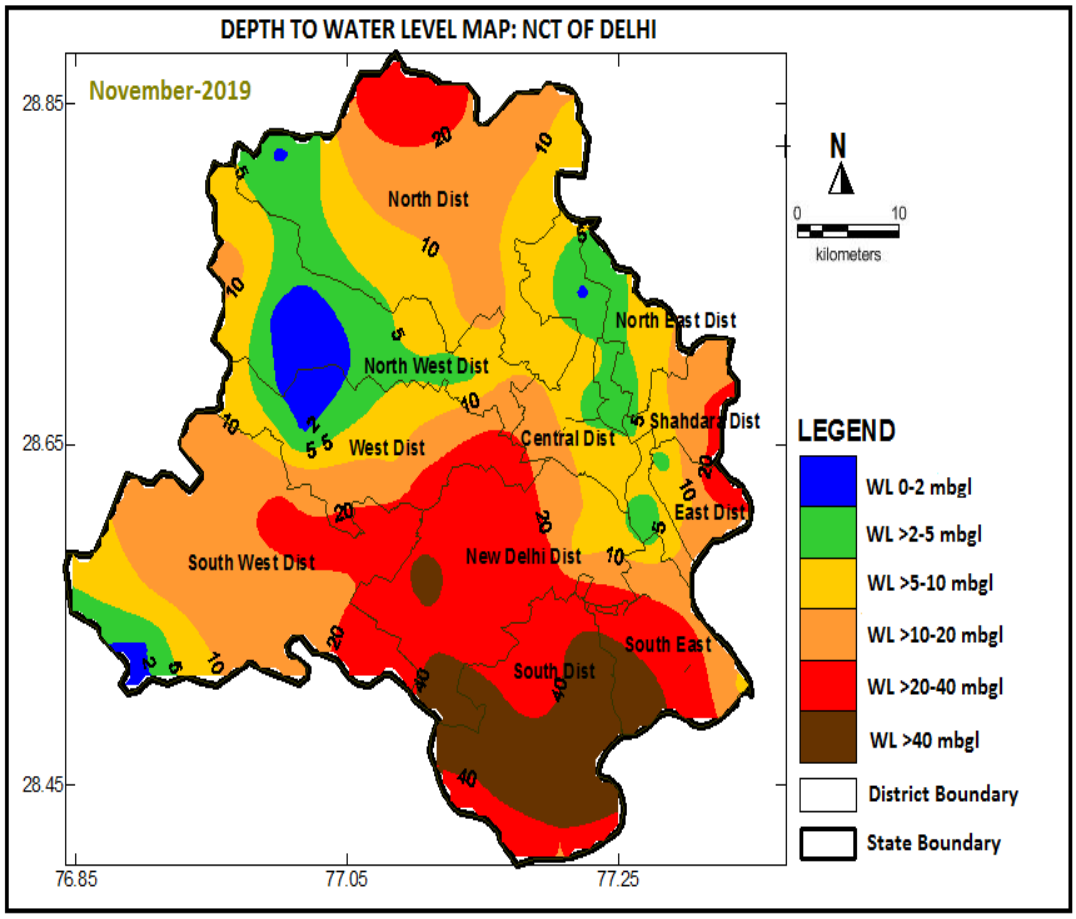
Figure:12



3.2. Post Monsoon Water Level – November 2019

Post monsoon water levels are monitored in the month of November 2019 (Figure 13). The Depth to water level recorded in NCT Delhi during **November-2019** ranges from 0.3 at Deorala to 63.15 mbgl at Gadaipur. About 15% of NCT Delhi areas, in parts of North, North West, Northeast, East, Central, Nazul land, West and Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 60 m observed in around 33% of NCT Delhi, in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 52 % areas have water level in range of 5 to 20 mbgl.

Figure: 13



3.3. Decadal Mean (2010-19) Pre-Monsoon and Post-Monsoon Water Level.

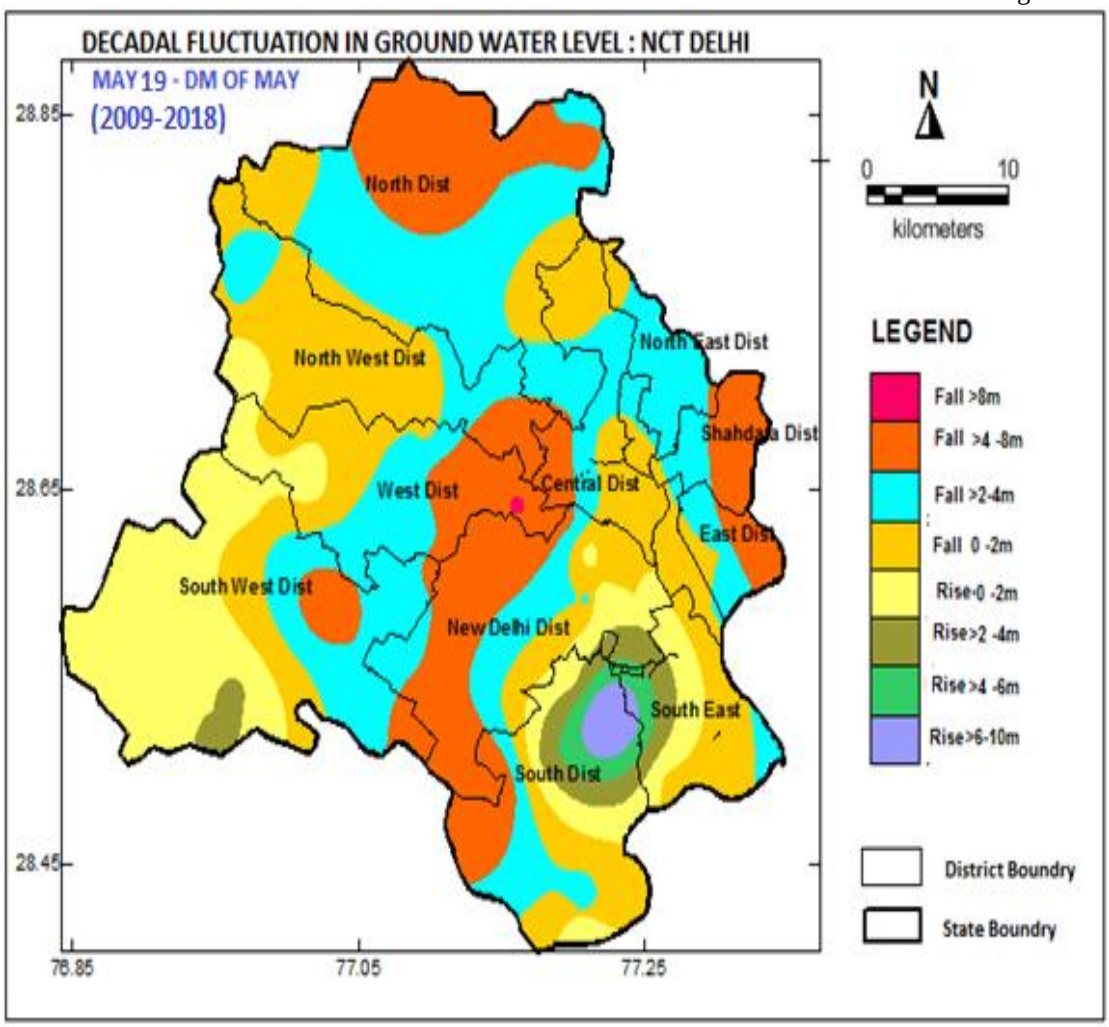
Decadal mean of pre-monsoon and post-monsoon water level 2010-2019 period is considered to estimate dynamic ground water resources of 34 assessment units of NCT Delhi. The pre-monsoon decadal mean of Northern districts ranges from 2.25 to 18.47 mbgl., Eastern districts ranges from 2.41 to 19.61 mbgl., Western districts ranges from 1.88 to 36.16 mbgl. and Southern districts ranges from 3.68 to 62.77 mbgl.

The post-monsoon decadal mean of Northern districts ranges from 1.21 to 19.98 mbgl., Eastern districts ranges from 1.66 to 19.88 mbgl., Western districts ranges from 2.16 to 36.36 mbgl. and Southern districts ranges from 3.66 to 60.71 mbgl.

3.4. Decadal Fluctuation: (Decadal Mean of May 2009-18 & May 2019)

Comparing water level data of May-2019 with 10 year mean water level of May (2009 to 2018), the change in water level ranges from -8.5 m to 12.97 m. About 76 % of monitoring wells show fall in water level of May 2019 when comparing decadal mean of May water level of 2009-18, whereas rest 24 % wells show rise in water levels. The rise mainly confined to western parts of South-West, West, North West and some parts New Delhi, East, Central and South East (Figure:14). About 27% areas show fall up to 2 m, 52% more than 2m. Similarly rise up to 2m is recorded in 16% areas and 5% areas shows rise in range to 2 to 4 m.

Figure :14

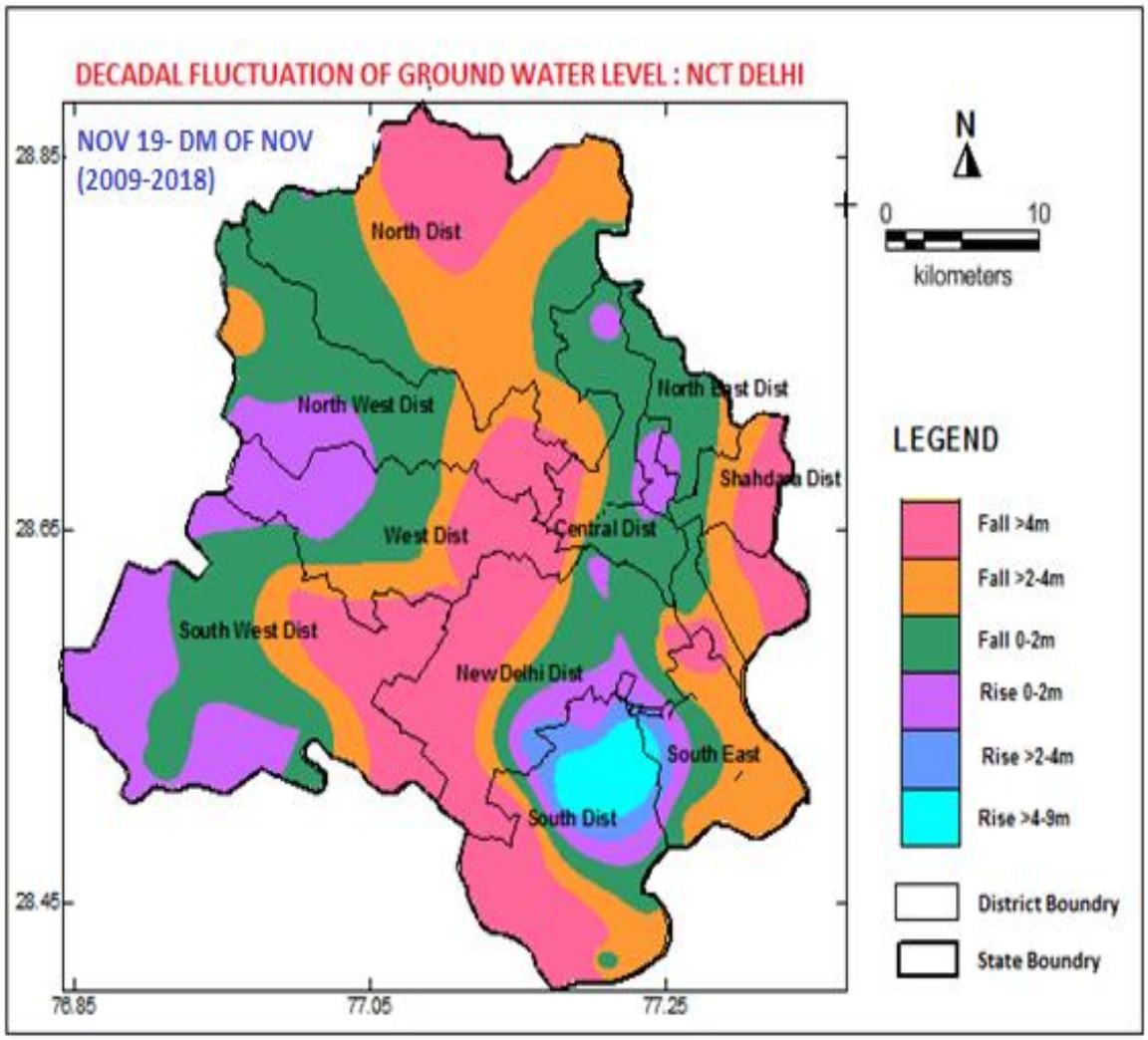


3.5 Decadal Fluctuation: (Decadal Mean of Nov 2009-18 & Nov2019)

Comparing water level data of November-2019 with 10 year mean water level of November (2009 to 2018), the change in water level ranges from -13.16 m to11.64 m. About 29% of monitoring wells show in rise of water level of November 2019, comparing decadal mean of November water level of 2009-18, whereas rest 71 % monitoring wells show fall of water level. This rise mainly confined to two parts of NCT Delhi; i.e. in western part of Southwest, West and Northwest districts and in Southeast, South and New Delhi district of NCT Delhi (Figure 15). About 33 % areas show fall up

to 2 m, 23% up to 4 m and rest 25% more than 4m. Similarly rise upto 2 m is recorded in 15% areas and 4 % areas shows rise more than 2m.

Figure:15



4. GROUND WATER QUALITY IN NCT DELHI

Chemical quality of ground water in NCT Delhi varies with depth and space. It is mainly influenced by local geology and inherent salinity, and uneven development of ground water. In alluvial formations, in general, the quality of ground water deteriorates with depth, which is variable in different areas. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards North-West. The thickness of fresh water zone is limited in most parts of west and southwest districts. Because of finer sediments in the aquifer, flushing of ground water is not proper and longer residence time of water in the aquifer results in dissolution of salts from the aquifer material, which leads to higher TDS content and in turn higher EC.

Besides ground water salinity, other chemical constituents are considered as per GEC 2015 methodology are Fluoride and Arsenic. Most of the fluoride found in ground water of NCT Delhi as point source, is naturally occurring from the breakdown of rocks and soils or outcome of weathering process. Most of the fluorides are sparingly soluble and are present in ground water in small amount. Arsenic, in general, not reported in parts of NCT Delhi in routine ground water monitoring taken up by SUO, CGWB work.

4.1. Salinity in Ground water

The ground water salinity (as measured by total dissolved solids) generally increases along the ground water flow path. Water from recharge areas is usually relatively fresh, whereas water from discharge areas is often relatively saline. Electrical Conductivity (EC) is field measure of salinity in ground water. EC can be measured quickly and easily, either in the laboratory or in the field. The readings are temperature dependent; therefore, measurements typically are corrected to an equivalent value at 25 degrees Celsius. The internationally accepted standard unit for reporting EC is *deciSiemens per meter (dS/m).* An older, equivalent unit is millimhos per centimeter.

1 dS/m = 1 m mho/cm = 1000 µ mho/cm or 1000µS/cm ……..S for Siemens

Its conversion to more common term Total Dissolved Solids (TDS), the following relation is used
TDS (in mg/L) = EC (in dS/m) × C
Where the value of coefficient (C) is 640, is appropriate for a fairly wide range of conditions. For waters of mixed composition, it is around 735 instead, and for concentrated solutions with EC exceeding 5 dS/m, it is around 800.

Most water used for irrigation has an EC in the range 0.1 to 1 dS/m. Waters that have EC in excess of 0.7 dS/m (corresponding to a TDS of about 450 mg/L) must be managed a bit more carefully if salinity problems are to be held in check. An EC of 3 dS/m (equivalent to a TDS of about 2000 mg/L) is the upper limit for irrigation as well as for drinking purpose.

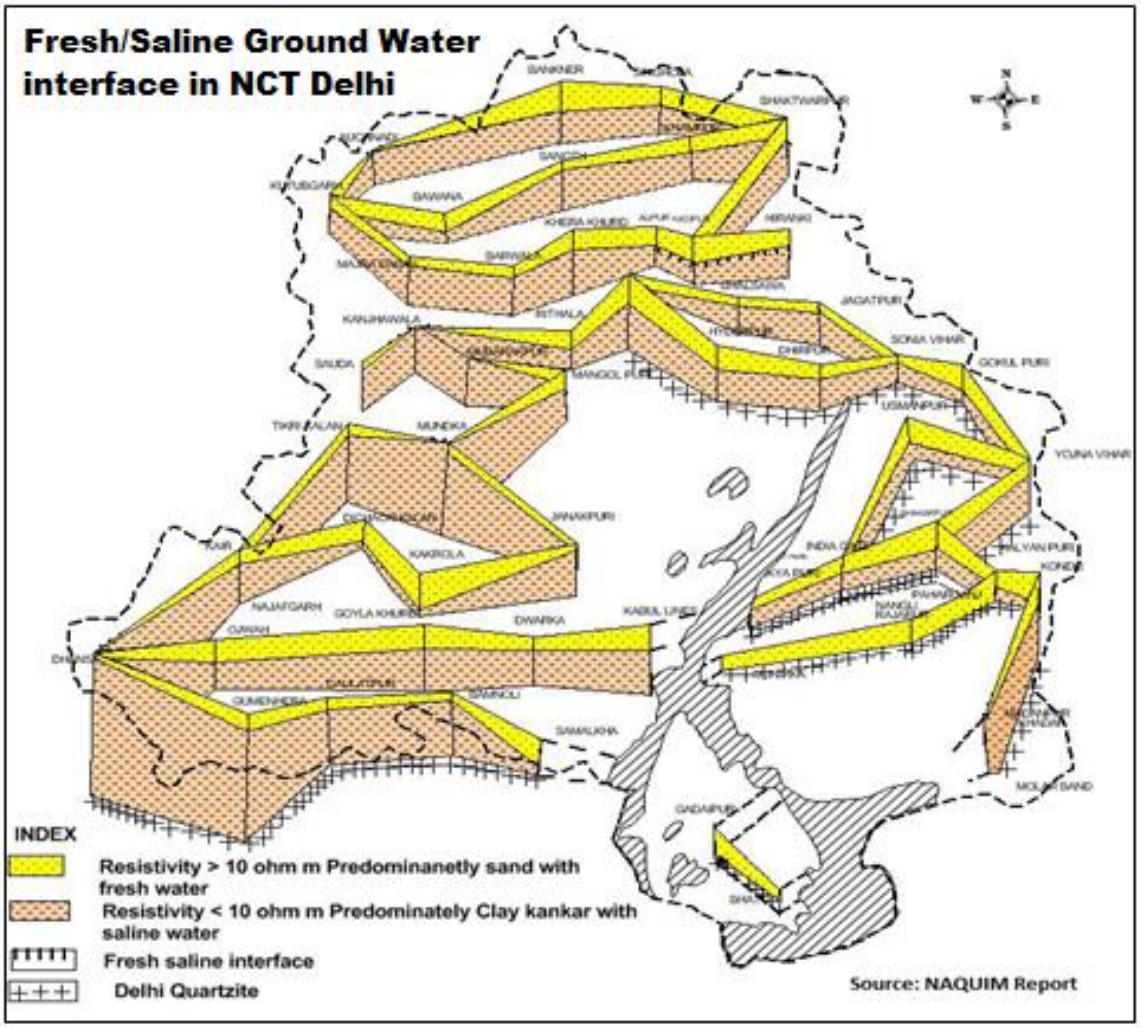
- **Distribution of Electrical Conductivity in Ground water**

The fresh ground water aquifers mainly exist up to a depth of 25 to 35 m in North West, West and parts of South west districts and in minor patches in North and Central districts. In South, Southeast & Southwest district, especially in Najafgarh Jheel area the fresh water occurs up to a depth of 30 to 45 m. A localized area located just north of Kamala Nehru Ridge (part of

Delhi ridge falling in Central District) covering area of Dhirpur, Wazirabad and Jagatpur are characterized by shallow depth of fresh water aquifers that is in the range of 22 to 28m, regardless of proximity to River Yamuna. In the flood plains of Yamuna, in general, fresh water aquifers exist down to depth of 30m-45m and especially in Palla, it reaches to the depth of 60 to 75m below which brackish and saline water exists. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and eastern part (Ridge Area) of South-West districts and in Chattarpur basin.

A fence diagram showing fresh / saline ground water interface, in NCT Delhi, as reported in NAQUIM project of CGWB is presented in Figure 16. On basis of this vertical distribution of fresh / saline ground water depth zones in each assessment units *Dynamic* -fresh / saline and *Static* – fresh / saline are worked out in NCT Delhi (**Annexure III**).

Figure: 16



5. "INDIA-Groundwater Resource Estimation System (IN-GRES)"

Assessment of 'Dynamic Ground Water Resources of India' is carried out at periodical intervals jointly by the Central Ground Water Board (CGWB) and State/UT Ground Water Departments under the guidance of State Level Committee at State levels and under the overall supervision of Central Level Expert Group. Last assessment was carried out in 2017 and re-assessment of Dynamic Ground Water Resources of India, 2020 has been carried out based on the norms and guidelines of Ground Water Resource Estimation Committee (GEC-2015) methodology.

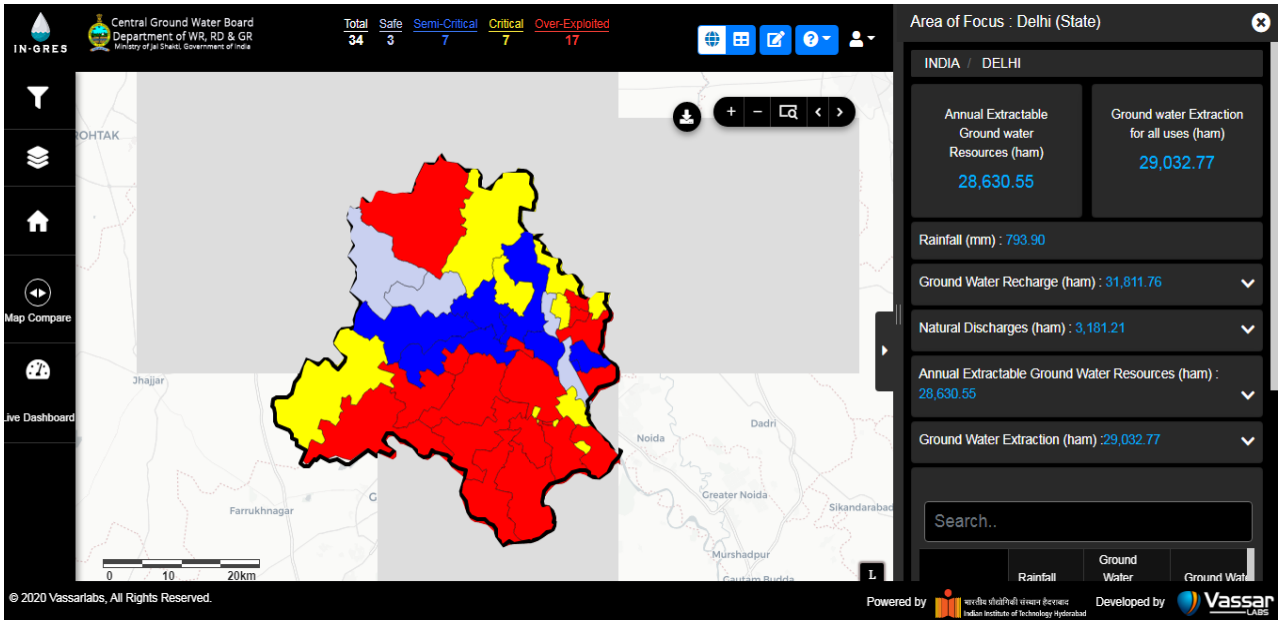
The assessment involves computation of Annual Ground Water Recharge and Annual Extractable Ground Water Resources, Total Annual Ground Water Extraction (utilization) and the percentage of utilization with respect to Annual Extractable Ground Water Resources (Stage of Extraction). The assessment units (blocks/taluks/mandals/tehsil/firkas etc.) are categorized based on the Stage of Extraction (SoE) i.e 'Safe' if SoE < 70 %; 'Semi-critical if SoE> 70 and <= 90 %; 'Critical' if SoE>90 and <=100 % and 'Over-exploited' if SoE> 100 %.

"INDIA-Ground Water Resource Estimation System (IN-GRES)" is a software/web-based application developed by Central Ground Water Board (CGWB) in collaboration with Indian Institute of Technology-Hyderabad (IIT-H) for assessment of ground water resources.

Objectives

1. To provide common and standardized platform for Ground Water Resource Assessment for the entire country based on Ground Water Resource Estimation Committee-2015 (GEC-2015) methodology.
2. Pan-India operationalization (Joint assessment by CGWB and State Ground Water/ Nodal Departments).
3. Visibility dashboards allowing user to view the data/map and download reports (Figure 17).

Figure: 17



6. GEC 2015 METHODOLOGY

Present Ground water Resource Estimation 2020 (GWRE 2020) has been carried as per revised methodology, known as Ground water Estimation Committee 2015 (GEC 2015). The foremost recommendations of revised GEC 2015 methodology are summarized as follows. Detailed report on GEC 2015 is available on CGWB web site (http://cgwb.gov.in/).

6.1. Concept of Aquifer Wise Assessment

GEC 2015 recommends aquifer wise ground water resource assessment for Replenishable ground water resources or Dynamic ground water resources and for In-storage ground water resources or Static ground water resources for both Unconfined and Confined aquifer. Wherever the aquifer geometry has not been firmly established for the unconfined aquifer, the in-storage ground water resources must be assessed in the alluvial areas up to the depth of bed rock or 300m whichever is less. In case of hard rock aquifers, the depth of assessment would be limited to 100m. In case of confined aquifers, if it is known that ground water extraction is being taken place from this aquifer, the dynamic as well as in-storage resources are to be estimated. If it is firmly established that there is no ground water extraction from this confined aquifer, then only in-storage resources of that aquifer must be estimated.

6.1.1. Periodicity of Assessment

GEC 2015 methodology recommends that the ground water resources should be assessed once in every three years as per the present practice such that time lag between assessment and publication of the results be minimized.

6.1.2. Ground water Assessment Unit & Sub Units

GEC 2015 methodology recommends aquifer wise ground water resource assessment. However, until aquifer geometry is established on appropriate scale, it recommends that the existing practice of using watershed in hard rock areas and blocks/ mandals/ firkas in soft rock areas may be continued. In case of NCT Delhi, Tehsil Subdivision boundary has been considered as assessment unit. In all it is 33 Tehsils plus one Nazul Land has also been considered as assessment unit. Hence, there are 34 assessment units in NCT, Delhi.

Like earlier GEC methodology, out of the total geographical area of the assessment unit, hilly areas wherever slope is greater than 20%, are to be identified and subtracted as these areas have more runoff than infiltration. No such area is identified in Delhi where slope is more that 20%.

The ground water resource beyond the permissible quality limits in terms of the salinity has to be computed separately. There is a small patch in NCT, Delhi where Salinity in ground water is reported from ground level. However, saline ground water occurs at very shallow depth. GEC 2015 methodology recommends that after the assessment is done, a quality flag may be added to the assessment unit for parameters salinity, fluoride and arsenic. It is proposed to have all these areas of an assessment unit in integer hectares to make it national database with uniform precision.

6.1.3. Ground Water Resources of Assessment of Unit

The ground water resources of any assessment unit are the sum of the total ground water availability in the principal aquifer (mostly unconfined aquifer) and the total ground water availability of semi-confined and confined aquifers existing in that assessment unit. The total ground water availability of any aquifer is the sum of Dynamic ground water resources and the In-storage or Static resources of the aquifer.

GEC 2015 advocate that the development planning should be on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

6.2. Assessment of Annually Replenishable or Dynamic Ground water Resources

The elementary concept of GEC 2015 methodology for ground water resources estimation is based on basic principle of water balance as given below –

Inflow – Outflow = Change in Storage (of an aquifer) **1**

Equation 1 can be further elaborated as -

ΔS= Rrf+RSTR+RC+RSWI+RGWI+RTP+RWCS±VF ± LF -GE-T-E-B **2**

Where,

ΔS –	Change is storage
Rrf –	Rainfall recharge
RSTR-	Recharge from stream channels
Rc –	Recharge from canals
RSWI –	Recharge from surface water irrigation
RGWI-	Recharge from groundwater irrigation
RTP-	Recharge from Tanks & Ponds
RWCS –	Recharge from water conservation structures
VF –	Vertical flow across the aquifer system
LF-	Lateral flow along the aquifer system (through flow)
GE-	Groundwater Extraction
T-	Transpiration
E-	Evaporation
B-	Base flow

GEC 2015 has observed that although above mentioned components of water balance equation are imperative, the present status of database available with Government and non-government agencies is not adequate in most of the assessment units. Therefore, it is proposed that at present the water budget may be restricted to the major components only taking into consideration certain reasonable assumptions. The estimation is to be carried out using lumped parameter estimation approach keeping in mind that data from many more sources if available may be used for refining the assessment.

6.2.1. Rainfall Recharge

GEC 2015 recommended that monsoon rainfall recharge should be estimated on ground water level fluctuation and specific yield approach. This, however, requires adequately spaced representative water level measurement for a sufficiently long period. It is proposed

that there should be at least three spatially well distributed observation wells in the assessment unit, or one observation well per 100 Sq.km. Water level data should also be available for a minimum period of 5 years (preferably 10 years), along with corresponding rainfall data. Regarding frequency of water level data, three water level readings during pre and post monsoon seasons and in the month of January/ May preferably in successive years, are the minimum requirements. It would be ideal to have monthly water level measurements to record the peak rise and maximum fall in the ground water levels. In units or subareas where adequate data on ground water level fluctuations are not available as specified above, ground water recharge may be estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season may be estimated using rainfall infiltration factor method only.

- **Water Level Fluctuation (WLF) Method**

Under this method the change in storage is computed by multiplying water level fluctuation between pre and post monsoon seasons with the area of assessment and specific yield.
Change in Storage = $\Delta S = h * Sy * A$ …… (i)
Where,
h = rise in water level due to monsoon (fluctuation between pre-monsoon and post-monsoon water level),
A = area for computation of recharge, and
Sy = specific yield of aquifer formation

The Specific yield of a soil or rock is the ratio of the volume of water that, after saturation, can be drained by gravity to its own volume (Todd & Mays, 2005). The Specific yield data have either been arrived through field studies, including long-duration pumping tests and dry season ground water balance (in hard-rock areas) or adopted from the norms recommended by GEC-1997, which were derived from the various water-balance studies carried out by CGWB, SGWDs and academic/research institutions. The range of specific yield recommended by GEC 2015 for different formations of Delhi is presented in Annexure IV**.**

Substituting the expression in equation 1 for storage increase ΔS in terms of water level fluctuation and specific yield, rainfall recharge in non-command will be as follow:

$$R_{RF} = h \times Sy \times A - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \quad 3$$

and considering another term Rc as Recharge due to canals, rainfall recharge equation in command will be as follows:

$$R_{RF} = h \times Sy \times A - R_{C} - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \quad 4$$

The recharge calculated from equation 3 in case of non-command sub units and equation 4 in case of command sub units and poor ground water quality sub units gives the rainfall recharge for the particular monsoon season. However, it may be noted that in case base flow/ recharge from stream and through flow have not been estimated, the same may be assumed to be zero. The rainfall recharge obtained by using equation 3 & equation 4 provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate is to be normalized for the normal monsoon season rainfall as per the procedure indicated below.

- **Normalization of Rainfall Recharge**

The recharge from rainfall estimated as per the above is for the particular monsoon season. It should be normalized for estimating recharge corresponding to the normal monsoon rainfall.

The methodology for normalizing monsoon recharge, is summarized below.

The computational procedure to be followed is as given below:

$$Rrf(normal) = \frac{\Sigma_{i=1}^{N} \left(R_i \frac{r(normal)}{r_i} \right)}{N}$$

Where,
Rrf (normal) = Normalized Rainfall Recharge in the monsoon season.
R_i = Rainfall Recharge in the monsoon season for the i^{th} year.
r(normal) = Normal monsoon Season rainfall.
r_i = Rain fall in the monsoon season for the i^{th} year.
N = Number of years data is available.

- **Rainfall Infiltration Factor (RIF) Method**

Like earlier GEC methodology, GEC 2015 recommended to compare the rainfall recharge obtained from Water Level Fluctuation approach with that estimated using Rainfall Infiltration Factor Method.
Recharge from rainfall is estimated by using the following relationship -
Rrf = RFIF * A* (R – a)/1000
Where,
Rrf = Rainfall recharge in ham
A = Area in Hectares
RFIF = Rainfall Infiltration Factor (in fraction)
R = Rainfall in mm
a = Minimum threshold value above which rainfall induces ground water recharge in mm

GEC 2015 suggest that 10% of Normal annual rainfall be taken as Minimum Rainfall Threshold and 3000 mm as Maximum Rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall is to be deducted from the monsoon rainfall and balance rainfall would be considered for computation of rainfall recharge. The same recharge factor may be used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall may be taken as zero, if the normal rainfall during the non-monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non-monsoon rainfall may be estimated for normal rainfall, based on recent 30 to 50 years of data.

- **Percent Deviation**

After computing the rainfall recharge for normal monsoon season rainfall using the Water level Fluctuation method and Rainfall Infiltration Factor method these two estimates have to be compared with each other. A term, Percent Deviation (PD) which is the difference between the two expressed as a percentage of the former is computed as

$$PD = \frac{R_{rf\ (normal,wlfm)} - R_{rf\ (normal,rifm)}}{R_{rf\ (normal,wlfm)}} \times 100$$

where,

Rrf (normal, wlfm) = Rainfall recharge for normal monsoon season rainfall estimated by the water level fluctuation method

Rrf (normal, rifm) = Rainfall recharge for normal monsoon season rainfall estimated by the rainfall infiltration factor method

The rainfall recharge for normal monsoon season rainfall is finally adopted as per the criteria given below:

- If PD is greater than or equal to -20%, and less than or equal to +20%, Rrf (normal) is
- taken as the value estimated by the water level fluctuation method.
- If PD is less than -20%, Rrf (normal) is taken as equal to 0.8 times the value estimated by the rainfall infiltration factor method.
- If PD is greater than +20%, Rrf (normal) is taken as equal to 1.2 times the value estimated by the rainfall infiltration factor method.

During the period 2019 – 2020, above calculation, normalization, estimation of PD and consideration of rainfall recharge is taken care by INGRES software. Basic data pertaining to Rainfall, Water level, Specific Yield, Infiltration faction factor, Paved area, Buildup area and open area have been provided to Software. The NCT Delhi being urban area which have more than 60% build up area do not support rainfall recharge at all places.

6.2.2. Recharge from other Sources

Recharge from other sources constitute recharges from canals, surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures in command areas where as in non-command areas the recharge due to surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures are possible.

- **Recharge from Canals**

Recharge due to canals is to be estimated based on the following formula:

RC = WA * SF * Days

Where:

RC = Recharge from Canals
WA = Wetted Area
SF = Seepage Factor
Days = Number of Canal Running Days.

The NCT Delhi have very small length of Canal that too lined, support very little recharge.

- **Recharge from Surface Water Irrigation**

Recharge due to applied surface water irrigation, either by means of canal outlets or by- lift irrigation schemes is to be estimated based on the following formula:

RSWI =AD*Days*RFF

Where:

RSWI = Recharge due to applied surface water irrigation
AD = Average Discharge
Days = Number of days water is discharged to the Fields
RFF = Return Flow Factor

The NCT Delhi use treated water and canal water for irrigation in small area which is existing only in North & North West district, so impact of recharge is limited to this area only

- **Recharge from Ground water Irrigation**

Recharge due to applied ground water irrigation is to be estimated based on the following formula:

RGWI = GEIRR*RFF

Where:

RGWI = Recharge due to applied ground water irrigation
GEIRR = Ground water Extraction for Irrigation
RFF = Return Flow Factor

The ground water used by Horticulture department, Forest department, PWD and State & Central agencies of NCT Delhi for green belt development have been used as irrigation by ground water.

- **Recharge due to Surface Water Bodies**

Recharge due to surface water bodies, like tanks & ponds etc is to be estimated based on the following formula:

R_{TP} =AWSA*RF

Where:

R_{TP} = Recharge due to Tanks & Ponds
AWSA = Average Water Spread Area
RF = Recharge Factor

Data provided by DJB & wetland authority of NCT Delhi have been used by averaging water spread & recharge factors for each Tehsil.

- Recharge due to Water Conservation Structures

Recharge due to Water Conservation Structures is to be estimated based on the following formula:

R_{WCS} =GS*RF

Where:

R_{WCS} = Recharge due to Water Conservation Structures
GS = Gross Storage (Storage Capacity multiplied by number of Fillings).
RF = Recharge Factor

Delhi Jal Board, being the Nodal Agency to keep account of water conservation structure, has provided comprehensive data pertaining to water conservation structure spread all over Delhi. Many authorities such as CPWD, Indian Railway & PWD has failed to provide data regarding Water Conservation Structures created by them during 2017 – 2019, hence, there is scope for refinement of estimation of recharge from water conservation structures.

The NCT Delhi, being urban area, have very dense network of piped water supply and sewer system. The piped water supply is only 80% efficient and remaining 20% is leaking and recharging to ground water. This have been used while estimating recharge from other sources depending on tehsil wise status of water supply & source of water supply.

6.2.3. Recharge During Monsoon Season

The sum of normalized monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into the sub unit and stream inflows during monsoon season is the total recharge during monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.4. Recharge During Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using Rainfall Infiltration Factor method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into the sub unit and stream inflows during non-monsoon season is the total recharge during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.5. Total Annual Ground Water Recharge

The sum of the recharge during monsoon and non-monsoon seasons is the total annual ground water recharge for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.6. Annual Extractable Ground Water Recharge (EGR)

The National Water Policy, 2012 stresses that the ecological flow of rivers should be maintained. Accordingly, GEC 2015 recommends that ground water base flow contribution limited to the ecological flow of the river should be determined which will be deducted from Annual Ground water Recharge to determine Annual Extractable Ground water Resources (EGR). The ecological flows of the rivers are to be determined in consultation with Central Water Commission and other concerned river basin agencies. In the assessment units, where river stage data are not available and neither the detailed data for quantitative assessment of the natural discharge are available, present practice (GEC 1997) of allocation of unaccountable natural discharges to 5% or 10% of annual recharge may be retained. If the rainfall recharge is assessed using Water Level Fluctuation method this will be 5% of the annual recharge and if it is assessed using Rainfall Infiltration Factor method, it will be 10% of the annual recharge. The balance will account for Annual Extractable Ground water Resources (EGR).

6.3. Estimation of Ground water Extraction

GEC 2015 recommend various available methods for estimation of ground water extraction in each assessment sub unit, as described below. Moreover, GEC 2015 also recommends that the ground water extraction obtained figures from different methods need to be compared and based on field checks, the seemingly best value may be adopted. At times, ground water extraction obtained by different methods may vary widely. Moreover, unit Extraction adopted needs to be normalized as per annual rainfall of period for which assessment is being carried out. In general, the value matching the field situation should be considered. It is also suggested that the storage depletion during a season where other recharges are negligible can be taken as ground water extraction during that particular period.

6.3.1. Normalization of Ground water Extraction

GEC-1997 recommended to use well census method for computing the ground water extraction. The norm used for computing ground water extraction is the unit Extraction. The unit Extraction can be computed by field studies. This method involves selecting representative abstraction structure and calculating the discharge from that particular type of structure and collecting the information on how many hours of pumping is being done in various seasons and number of such days during each season. The Unit Extraction during a particular season can be computed using the following equation:

Unit Extraction m^3 / hr = discharge in m^3 / hr X number of pumping hrs X numbers of days

GEC 2015 recommends normalization of unit Extraction figures as either of following two simple techniques, as per available data. If the unit Extraction values for one rainfall cycle are available for at least 10 years following equation second method is to be followed or else the first method shown in equation may be used.

$$\text{Normalised Unit Extraction} = \frac{\text{Unit Extraction} \times \text{Rainfall for the year}_{all}}{\text{Noramall Rainfall}_{all}} \quad 1$$

$$\text{Normalised Unit Extraction} = \frac{\sum_{i=1}^{n} \text{Unit Extraction}_i}{\text{Number of Years}} \quad 2$$

Although GEC-1997 methodology recommends a default value for the unit Extractions and each State is using its own values, generally after conducting field studies, even though without a documentation. GEC 2015 recommends that this norm may be computed by the state agency after conducting field studies before commencement of the assessment and should be documented and submitted along with the results of the assessment.

6.3.2. Components of Ground water Extractions

Ground water Extraction or extraction is to be assessed as follows.

GEALL = GEIRR + GEDOM + GEIND

Where,

GALL = Ground water extraction for all uses
GEIRR = Ground water extraction for irrigation
GE**DOM** = Ground water extraction for domestic uses
GEIND = Ground water extraction for industrial uses

- **Ground water Extraction for Irrigation (GEIRR)**

Unit Extraction Method: – In this method, season-wise unit Extraction of each type of well in an assessment unit is estimated. The unit Extraction of different types (eg. Dug well, dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure. It is recommended that a single source of well census should be maintained for resources computation at all India level. Minor Irrigation Census of MoWR, RD, GR would be the preferred option.

- **Ground water Extraction for Domestic Use (GEDOM)**

Unit Extraction Method: – In this method, unit Extraction of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water Extraction.
Consumptive Use Method: – In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation.
GEDOM= Population X Consumptive Requirement X Lg
Where,
Lg = Fractional Load on Ground water for Domestic Water Supply
The data about load factors on ground water sources can be obtained from the concerned water supply agencies / departments in urban areas.

- **Ground water Extraction for Industrial use (GEIND)**

Unit Extraction Method: - In this method, unit Extraction of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.
Consumptive Use Pattern Method: – In this method, water consumption of different industrial units are determined. Number of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water Extraction for industrial use, as suggested below.

GEIND= Number of industrial units X Unit Water Consumption X Lg
Where,
Lg = Fractional load on ground water for industrial water supply
The load on Ground water for Industrial water supply can be obtained from water supply agencies in the Industrial belt.
Data Base of Industry: -Other important sources of data on ground water extraction for industrial uses are - Central Ground Water Authority, State Ground Water Authority, National Green Tribunal and other Environmental Regulatory Authorities.

6.4. Stage of Ground water Extraction
The stage of ground water extraction is defined by,

$$Stage\ of\ GW\ Extraction = \frac{Existing\ Gross\ Ground\ water\ Extraction\ For\ All\ Uses}{Annual\ Extractble\ Ground\ water\ Resources} \times 100$$

The existing gross ground water extraction for all uses refers to the total of existing gross ground water extraction for irrigation and all other purposes. The stage of ground water extraction should be obtained separately for command areas, non-command areas and poor ground water quality areas.

6.4.1. Validation of Stage of Ground water Extraction

Taking into consideration of inherent uncertainties associated with various component of both extracted and extractable ground water resources, GEC 1997 has recommended to validate the "Stage of Ground water Extraction (SGE)" with long term trend of ground water levels for a minimum period of 10 years for both pre-monsoon and post-monsoon period.

GEC 2015 refine these concepts further and suggest that if the pre and post monsoon water levels show a fairly stable trend, it does not necessarily mean that there is no scope for further ground water development. Such a trend indicates that there is a balance between recharge, extraction and natural discharge in the unit. However, further ground water development may be possible, which may result in a new stable trend at a lower ground water level with associated reduced natural discharge. If the ground water resource assessment and the trend of long-term water levels contradict each other, this anomalous situation requires a review of the ground water resource computation, as well as the reliability of water level data. The mismatch conditions are enumerated below Table 7.

Table 7: Validation Criteria for Stage of GW Extraction (SGWE)

Stage of GW Extraction	Ground water Level Trend	Remarks
$\leq 70\ \%$	Decline in trend in both pre-monsoon and post-monsoon	Not acceptable and needs reassessment
$> 100\ \%$	No significant decline in both pre-monsoon and post-monsoon long term trend	Not acceptable and needs reassessment

In case, the category does not match with the water level trend given above, a reassessment should be attempted. If the mismatch persists even after reassessment, the sub unit may be categorized based on Stage of Ground Water Extraction of the reassessment. However, the sub unit should be flagged for strengthening of observation well network and parameter estimation.

6.4.2. Categorization of Assessment Units

Present categorization of assessment units, as per GEC 1997 methodology takes into account long term ground water level trends and stage of ground water extraction of period under consideration. The National Water Policy, 2012 emphasis a convergence of quantity and quality of ground water resources while assessing the ground water extraction status in an assessment unit so as to aid appropriate management decisions. Therefore, GEC 2015 recommends to separate estimation of resources where water quality is beyond permissible limits for the parameter salinity. Moreover, if any of the three quality hazards in terms of Arsenic, Fluoride and Salinity are encountered in the assessment sub unit in mappable units, the assessment sub unit may be tagged with the particular Quality hazard. Accordingly, GEC 2015 recommends that each assessment unit, in addition to the quantity based categorization (safe, semi-critical, critical and over-exploited) should bear a quality hazard identifier (Table 8). Such quality hazards are to be based on available ground water monitoring data of State Ground Water Departments and /or Central Ground Water Board.

Table 8: Criteria for Quantity & Quality Based Categorization

Stage of Ground water Extraction	Category	Quality Tag
$\leq 70\ \%$	Safe	Tag for sub unit / unit in terms of Salinity, Arsenic, Fluoride, if any
$> 70\ \%\ and\ \leq 90\ \%$	Semi Critical	
$> 90\ \%\ and\ \leq 100\ \%$	Critical	
$> 100\ \%$	Over Exploited	

6.4.3. Allocation of Ground water Resource for Utilization

The Annual Extractable Groundwater Resources are to be apportioned between domestic, industrial and irrigation uses. Among these, as per the National Water Policy, requirement for domestic water supply is to be accorded priority. This requirement has to be based on population as projected to the year 2025, per capita requirement of water for domestic use, and relative load on ground water for urban and rural water supply. The estimate of allocation for domestic water requirement may vary for one sub unit to the other in different states. In situations where adequate data is not available to make this estimate, the following empirical relation is recommended.

Alloc = 22 X N X L_g mm per year

Where

Alloc = Allocation for domestic water requirement

N = population density in the unit in thousands per sq. km.

Lg = fractional load on groundwater for domestic and industrial water supply (≤ 1.0)

In deriving equation above, it is assumed that the requirement of water for domestic use is 60 lpd per head. The equation can be suitably modified in case per capita requirement is different. If by chance, the estimation of projected allocation for future domestic needs is less than the current domestic extraction due to any reason, the allocation must be equal to the present-day extraction. It can never be less than the present-day extraction as it is unrealistic.

6.4.4. Net Annual Ground Water Availability for Future Use

The water available for future use is obtained by deducting the allocation for Domestic use and current extraction for Irrigation and Industrial uses from the annual extractable ground water recharge. The resulting ground water potential is termed as the Net Annual Ground Water Availability for future use.

The net annual ground water availability for future use should be calculated separately for non-command areas and command areas. As per the recommendations of the R&D Advisory committee, the ground water available for future use can never be negative. If it becomes negative, the future allocation of domestic needs can be reduced to current extraction for domestic use. Even then if it is still negative, then the ground water available for future uses will be zero.

6.5. Ground water Assessment in Urban Areas

GEC 2015 propose to have a separate ground water assessment for urban areas with population more than 10 lakhs. Taking note of difficulties to have ground water Extraction data in most of the urban areas and constraints to natural recharge, by rainfall infiltration and recharge due to other sources on account of urbanization, GEC 2015 has suggested the following few points are to be considered for Urban Areas Ground Water Resources Estimation.

- The difference of the actual demand and the supply by surface water sources as the withdrawal from the ground water resources.
- Consider 30% of the rainfall infiltration factor for urban areas as an adhoc arrangement till field studies are done and documented.

- The 50 % percent losses reported by piped water supply may be taken as recharge to the ground water system.
- The seepages from the sewerages, which normally contaminate the ground water resources with nitrate also contribute to the quantity of resources and hence same percent as in the case of water supply pipes may be taken as norm for the recharge on the quantity of sewerage when there is sub surface drainage system.
- Recharge on account of seepage from open drainage system / open channels, (like lined / unlined canal) may be considered, till further documented field studies are done.
- If estimated flash flood data is available, the same percent can be used on the quantum of flash floods to estimate the recharge from the flash floods.

6.6. Ground water Assessment in Water Level Depletion Zone

In some of assessment unit there may be areas where ground water level shows a decline even in the monsoon season. The reasons for this may be genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge.

GEC 2015 suggest that, if it is concluded that the water level data is erroneous, recharge assessment may be made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method may be applied for recharge estimation. In such cases, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones will be that the area falls under the overexploited category which requires micro level study.

7. GROUND WATER RESOURCE ESTIMATION 2020

The Ground water Resource Estimation 2020 (GWRE 2020), NCT Delhi has been carried out broadly following GEC-2015 methodology. In absence of requisites data or inadequacy if any, the constraints and the procedure followed in the present assessment are described below.

7.1. Data Sources and Constraint for Various Data Elements

All efforts are made to collect the data from the respective State Government Departments. However, it is felt necessary to mention that due to non-availability of data from some departments, certain assumptions have made while making the computations. Essential data sets were generated by approximate methods by fitting a relationship with the existing data elements and the required data elements wherever both are available and used the equation for rest of the area. The data sources for the various data elements used in the present exercise are presented in Table 9.

Table 9: Data Sources Used in the Ground Water Resource Estimation 2020

S. No	Data Element	Used in the Computation of	Data Source
1	Areas of Various sub units	Assessment unit wise recharge & Extraction component	List and maps of new administrative Units of 11 Districts of NCT Delhi: Revenue Dept, GNCT Delhi. web site & Geospatial Delhi Limited
2	Irrigation Well Census	Ground water extraction for irrigation	IV Minor Irrigation Census & Agriculture Dept of GNCT, I&FC
3	Population Census / Agriculture Area / Industry Census /	Ground water extraction for domestic, agriculture and industrial use	Census of India, Agriculture statistics of GNCT Delhi, List Industries on Industry Dept DPCC web site. DJB, Horticulture, Delhi Cantt, DMRC, DMC etc
4	Canal/Drains Details	Return Seepage Recharge due to Canals / Drains	I&FC Dept, GNCT of Delhi
5	Cropping Pattern	Return Seepage Recharge due to Surface Water Irrigation and Ground Water Irrigation.	IV Minor Irrigation Census & Agriculture Dept of GNCT Delhi
6	Details of Tanks & Ponds	Recharge due to Tanks & Ponds: ad-hoc basis	Statistical Book of GNCT Delhi / web link Parks & Garden, GNCT Delhi, DJB
7	Details of Water Conservation Structures	Recharge due to Water Conservation Structures	Delhi Jal Board (DJB)
8	Rainfall	Recharge due to Rainfall / Normalization of Rainfall Recharge	IMD, Govt of India web site
9	Ground Water Monitoring: Pre-monsoon and Post-monsoon groundwater levels & trends and GW quality monitoring data of last decade (2008-19).	Water Level Fluctuation method and validation of SGE; GW Quality data for identification of poor-quality area.	GEMS Database of SUO, New Delhi, Central Ground Water Board
10	Population Details	Provision for Future Domestic and Industrial Requirement.	Growth rate data of NCT Delhi as per Census of India, 2011 report.

Long term10 years (2008-19), pre-monsoon (May) and post-monsoon (November) water level data of observation wells monitored by CGWB, SUO Delhi are considered for calculating estimating zone of dynamic fluctuation and Water Level Trend. Water level fluctuations between pre-monsoon and post-monsoon have been calculated for hard rock and alluvial terrains separately. Water level data is presented in **Annexure IIa**. State agencies in NCT Delhi do not have any program for ground water monitoring and therefore recharge estimation relied on available data of CGWB. Monitoring station having data set pair, pre-monsoon and post-monsoon period, for more than 5 years considered. Some of the assessment units don't have sufficient representation for water level data. For such assessment units, monsoon recharge estimated by Rainfall Infiltration Factor, as suggested in GEC 2015 methodology is adopted.

For estimation ground water extraction for domestic water supply, data provided by different agencies were disseminated assessment unit wise based on coordinates. The cumulative ground water Extraction for drinking water for entire NCT Delhi cross checked with DJB data on difference in total water demand and supply from surface water source in NCT Delhi. Agriculture Extraction data was provided by I & FC and Agriculture department. The Extraction data provided by Horticulture & Forest department has been considered as Extraction for agriculture. The agriculture Extraction data provided by Agriculture department & I & FC department have been subsumed with that of Horticulture and Forest department to estimate agriculture Extraction. The Extraction due to Industry is worked out

as per area wise Industries /data available on web sites of Industry and DPCC site of GNCT of Delhi.

7.2. Assessment Unit Area

The ground water resource assessment of the NCT Delhi has been carried out considering tehsil as a unit assessment area. In total there are eleven (11) districts with three tehsils in each district of NCT Delhi, accounting for 33 assessment units and parts flood plain area around Yamuna River, which is demarcated as a Nazul land. The Nazul land areas is also considered as additional assessment unit. First time Ground water Resources Assessment had been attempted for these new administrative sub-units of NCT, Delhi in 2017. The Geospatial Delhi Limited, an undertaking under Department of Revenue of NCT Delhi has been requested to provided Tehsil wise area and GIS layer of NCT Delhi. The cumulative area for entire NCT Delhi worked out is 1486.67 Sq.km which nearly matches with total NCT area of 1483.00 Sq.km given in District Census Book of Delhi and accordingly, ground water resources assessment has been done for each of 33 tehsil and Nazul land areas considering total 1486 Sq.km of NCT Delhi. Some assessment units of NCT has surface water irrigation, constitute as a Canal Command Area. It is observed that such command has less than 100 ha in respective assessment units and therefore treated as Non-Command Area for resources estimation as per GEC 2015 methodology. The districts of South East, South, New Delhi and Central are covered with alluvial aquifers are fringed with hard rock aquifers viz. Delhi Quartzite occurring around Delhi ridge. Rest of the districts have alluvium aquifers only. Basic details of all 34-assessment units are presented in Table 10.

Table 10: Basic Details of Assessment Units of NCT Delhi – GWRE 2020

District	Assessment Unit	Predominant Rock Formation	Total Area (ha)	Hilly Area (Ha)	Recharge worthy area (Ha)	Poor Ground water quality (Ha)			Command Area (Ha)	Non-Command Area (Ha)
						As	Salinity	F		
1	2	3	4	5	6	7	8	9	10	11
CENTRAL	KAROL BAGH	Alluvium & HR	512.5	0	512.5	0	0	0	0	512.5
CENTRAL	KOTWALI	Alluvium	1964	0	1964	0	0	0	0	1964
CENTRAL	CIVIL LINES	Alluvium	5454	0	5454	0	0	0	0	5454
EAST	PREET VIHAR	Alluvium	1344	0	1344	0	0	0	0	1344
EAST	MAYUR VIHAR	Alluvium	1677	0	1677	0	0	0	0	1677
EAST	GANDHI NAGAR	Alluvium	138.9	0	138.9	0	0	0	0	138.9
NAZUL LAND	NAZUR LAND	Alluvium	2579	0	2579	0	0	0	0	2579
NEW DELHI	VASANT VIHAR	Alluvium & HR	5721	0	5721	0	Saline	0	0	5721
NEW DELHI	DELHI CANTONMENT	Alluvium & HR	6580	0	6580	0	Saline	0	0	6580
NEW DELHI	CHANAKYAPURI	Alluvium & HR	3508	0	3508	0	0	0	0	3508
NORTH	MODEL TOWN	Alluvium	2538	0	2538	0	Saline	0	0	2538
NORTH	ALIPUR	Alluvium	11818	0	11818	0	Saline	0	0	11818
NORTH	NARELA	Alluvium	14758	0	14758	0	Saline	0	0	14758
NORTH EAST	YAMUNA VIHAR	Alluvium	557.3	0	557.3	0	0	0	0	557.3
NORTH EAST	SEELAMPUR	Alluvium	895.9	0	895.9	0	0	0	0	895.9
NORTH EAST	KARAWAL NAGAR	Alluvium	2114	0	2114	0	0	0	0	2114
NORTH WEST	SARASWATI VIHAR	Alluvium	3299	0	3299	0	Saline	0	0	3299
NORTH WEST	KANJHAWALA	Alluvium	8039	0	8039	0	Saline	0	0	8039
NORTH WEST	ROHINI	Alluvium	4098	0	4098	0	0	0	0	4098
SHAHDARA	SHAHDARA	Alluvium	490.2	0	490.2	0	0	0	0	490.2
SHAHDARA	VIVEK VIHAR	Alluvium	2244	0	2244	0	0	0	0	2244
SHAHDARA	SEEMAPURI	Alluvium	724.3	0	724.3	0	0	0	0	724.3
SOUTH	SAKET	Alluvium & HR	7197	0	7197	0	0	0	0	7197
SOUTH	HAUZ KHAS	Alluvium & HR	2472	0	2472	0	0	0	0	2472
SOUTH	MEHRAULI	Alluvium & HR	6116	0	6116	0	0	0	0	6116
SOUTH EAST	SARITA VIHAR	Alluvium	3020	0	3020	0	0	0	0	3020
SOUTH EAST	DEFENCE COLONY	Alluvium & HR	3938	0	3938	0	0	0	0	3938
SOUTH EAST	KALKAJI	Alluvium & HR	3394	0	3394	0	0	0	0	3394
SOUTH WEST	KAPASHERA	Alluvium	10879	0	10879	0	Saline	0	0	10879
SOUTH WEST	DWARKA	Alluvium	6784	0	6784	0	Saline	0	0	6784
SOUTH WEST	NAJAFGARH	Alluvium	12853	0	12853	0	Saline	0	0	12853
WEST	RAJOURI GARDEN	Alluvium	1048	0	1048	0	Saline	0	0	1048
WEST	PATEL NAGAR	Alluvium	2646	0	2646	0	Saline	0	0	2646
WEST	PUNJABI BAGH	Alluvium	7360	0	7360	0	Saline	0	0	7360

7.3. Norms Followed in the Assessment GWRE 2020

The GEC 2015 recommends that the state agencies should be encouraged to conduct field studies for various norms and use such computed norms in the assessment. In absence of such computed norms by the field study, GEC 2015 suggests an average of the range of norms to be used as the recommended by GEC-1997. Detail of such norms are presented in GEC, 2015 report. The recommended norm values are to be used for assessment, unless sufficient data based on field study are available to justify the minimum, maximum or other intermediate values. Following are the range of norms suggested in GEC 2015 methodology (Table 11& 12).

7.3.1. Specific Yield

The Specific Yield values are used for the assessment units of NCT Delhi are as per its two main hydrogeological formation, alluvium as soft rock unit and Aravalli Group Quartzites

and related meta-sediment units, as mapped in NAQUIM project of CGWB. The portion of the specific yield norms recommended by GEC 2015, for aquifers underlain in NCT Delhi, is given in Table 11.

Table 11: Specific Yield Norms : GEC 2015 Methodology

Sl.No	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	6	4	8
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	10	8	12
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.5
41	Schist	SC02	Phyllite	Azoic to Proterozoic	1.5	1	2
42	Schist	SC03	Slate	Azoic to Proterozoic	1.5	1	2
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4

7.3.2. Rainfall Infiltration Factor

GEC 2015 recommends that Rainfall Infiltration Factor (RIF) values are to be used for assessment as per norm (Table 12) unless sufficient data based on field study is available to justify the minimum, maximum or other intermediate values. GEC 2015 recommends conducting field studies and strengthen the database norms. Moreover, for urban area assessment, GEC 2015 recommends adopting 30 % values of RIF norms on account of apparent reduction in rainfall infiltration due to urbanization. It is observed that, although most of the NCT Delhi is considered as Urban City, most of the assessment units have open space and green zones,

Table 12: Rainfall Infiltration Factor: GEC 2015 Methodology

Sl.No	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	22	20	24
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	22	20	24
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	22	20	24
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) -East Coast	Quaternary	16	14	18
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) - West Coast	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	22	20	24
7	Alluvium	AL07	Glacial Deposits	Quaternary	22	20	24
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
41	Schist	SC02	Phyllite	Azoic to Proterozoic	4	3	5
42	Schist	SC03	Slate	Azoic to Proterozoic	4	3	5
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3

which accommodate major part of rainfall infiltration like other non-urban areas. Therefore, except few assessment units of East Delhi and Central district, for major parts of NCT Delhi RIF value as per GEC 2015 norms and field observations of CGWB are adopted in GWRE 2020 is presented in Table 13. IMD Rainfall data adopted for GWRE 2020 is presented in Table 14.

Table 13: Norms adopted GWRE 2020, NCT Delhi

District	Assessment Unit Name	Normal Annual Rainfall (mm)	Normal Monsoon Rainfall (mm)	Specific Yield (%)	Method adopted for computing rainfall recharge during Monsoon recharge (WLF/RIF Method)	RF Infiltration Factor (%)
Central	Civil Lines Tehsil	793	667	12%	WLF	15%
Central	Karol Bagh Tehsil	793	667	12% & 1.5%	RIF	15% & 8%
Central	Kotwali Tehsil	793	667	12%	RIF	8%
East	Gandhi Nagar Tehsil	793	667	10%	RIF	8%
East	Mayur Vihar Tehsil	793	667	10%	WLF	8%
East	Preet Vihar Tehsil	793	667	10%	RIF	8%
New Delhi	Chanakyapuri Tehsil	793	667	12% & 1.5%	WLF	22% & 12%
New Delhi	Delhi Cantonment Tehsil	793	667	16% & 1.5%	WLF	22% & 12%
New Delhi	Vasant Vihar Tehsil	793	667	16% & 1.5%	RIF	22% & 12%
North	Alipur Tehsil	793	667	16%	WLF	22%
North	Model Town Tehsil	793	667	12%	RIF	12%
North	Narela Tehsil	793	667	12%	WLF	22%
North East	Karawal Nagar Tehsil	793	667	10%	RIF	12%
North East	Seelampur Tehsil	793	667	10%	WLF	12%
North East	Yamuna Vihar Tehsil	793	667	10%	WLF	12%
North West	Kanjhawala Tehsil	793	667	16%	WLF	22%
North West	Rohini Tehsil	793	667	16%	WLF	22%
North West	Saraswati Vihar Tehsil	793	667	16%	WLF	22%
Shahdara	Seemapuri Tehsil	793	667	10%	RIF	12%
Shahdara	Shahdara Tehsil	793	667	10%	WLF	12%
Shahdara	Vivek Vihar Tehsil	793	667	10%	RIF	12%
South	Hauz Khas Tehsil	793	667	20% & 4%	RIF	22% & 12%
South	Mehrauli Tehsil	793	667	20% & 4%	WLF	22% & 12%
South	Saket Tehsil	793	667	20% & 4%	WLF	22% & 12%
South East	Defence Colony Tehsil	793	667	12% & 1.5%	RIF	15% & 10%
South East	Kalkaji Tehsil	793	667	12% & 1.5%	RIF	12% & 22%
South East	Sarita Vihar Tehsil	793	667	12%	WLF	12%
South West	Dwarka Tehsil	793	667	16%	RIF	22%
South West	Kapashera Tehsil	793	667	16%	RIF	22%
South West	Najafgarh Tehsil	793	667	16%	RIF	22%
West	Patel Nagar Tehsil	793	667	16%	WLF	22%
West	Punjabi Bagh Tehsil	793	667	16%	WLF	22%
West	Rajouri Garden Tehsil	793	667	16%	WLF	22%
Nazul Land	Nazul Land Tehsil	793	667	10%	WLF	22%

Table: 14 Month & Season wise IMD Rainfall Data – NCT Delhi

Year	January	Febraury	March	April	May	June	July	August	September	October	November	December	Annual
2015	17.7	1.8	97.9	28.4	11.7	58.9	268.8	244.7	26.1	0.2	1.5	0	757.7
2016	0	1.1	17.9	0.1	22.5	59.7	312	103.1	48	3.5	0	0	567.9
2017	38.8	0	8.7	22.8	16	103.8	109.7	117	112.1	0	0.1	4.7	533.7
2018	4.8	0	0	12.2	18.6	57.4	247.6	185.8	148.7	0	3.8	0.5	679.4
2019	34.8	23.1	5.1	7.9	13.5	6.6	167.4	149.2	57.4	13.5	4.5	22.6	505.6
Average	**19.22**	**5.2**	**25.92**	**14.28**	**16.46**	**57.28**	**221.1**	**159.96**	**78.46**	**3.44**	**1.98**	**5.56**	**608.86**

Year	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Annual
2015	19.5	138	598.5	1.7	757.7
2016	1.1	40.5	522.8	3.5	567.9
2017	38.8	47.5	442.6	4.8	533.7
2018	4.8	30.8	639.5	4.3	679.4
2019	57.9	26.5	380.6	40.6	505.6

7.3.3. Norms for Canal Recharge

GEC 2015 recommends the norm in ham/million m^2 of wetted area for computing the recharge due to canals. In the absence of any field studies to refine the norms, it is recommended to continue with the same adhoc norms as of earlier GEC 1997. The committee strongly recommends that each state agency must conduct one filed study at least one in each district before completing the first assessment using this methodology and where specific results are available from case studies in some states, the adhoc norms are to be replaced by norms evolved from these results. In absence any field study, the norms adopted in earlier estimation are adopted in resent GWRE 2020 (Table 15).

Table 15: Norms for Recharge from Canals and Other Water Bodies

Parameters	Sources of Recharge	Range of Parameters
Canal Seepage Factor	Unlined Canals	15 to 30 ham / m sqm of wetted area
	Lined Canals & Canals in Hard Rock Terrain	20 % of above values suggested for lined canals
Seepage from Tanks & Ponds	1.4 mm / day over the average Water Spread Areas	
Recharge from Water Conservation Structures	40 % of the Gross Storage. Out of 50% during monsoon season and the remaining 50 % during non-monsoon season.	

7.3.4. Norms for Recharge Due to Other Sources

GEC 2015 has observed that the data on the field studies for computing recharge from other sources like tanks & ponds, Water Conservation Structures are very limited. It is recommended to follow the norms as per methodology when area specific field studies are not available. Accordingly, for recharge due to tanks & ponds, norm of 1.4 mm / day and for seepage recharge from Water Conservation Structures, norms of 40% of gross storage during

a year which means 20% during monsoon season and 20% during non-monsoon season is adopted (Table 15).

7.3.5. Norm for Future Allocation for Domestic Use

Per capita water requirement norm recommended by the GEC 2015 is 60 lpcd for domestic needs. It also suggested that it can be modified as per norm followed for domestic water supply agency in assessment unit if any for specific case. As per information made available from one of GNCT of Delhi report Economy Survey of NCT Delhi, same norm is considered by Delhi Jal Board, a water supplying agency in NCT Delhi. Future allocation for Domestic Use for 2025 has been estimated considering the said norms and dependency on ground water in respective Tehsil of NCT Delhi.

7.3.6. Norm for Natural Discharges

GEC 2015 recommends computing the base flow for each assessment unit. Wherever, there is no assessment of base flow, earlier norms recommended by GEC 1997 i.e. 5% if Water Table Fluctuation method is used or 10% if Rainfall Infiltration Factor method is used for assessing the rainfall recharge may be continued. Accordingly, the assessment unit component of Natural Discharge estimated, as per above norm corresponding WLF or RIF methodology adopted for estimating monsoon recharge is presented in Table 16.

7.4 Results of Groundwater Resources Estimation 2020

7.4.1 Annual Groundwater Recharge

The annual groundwater recharge includes the components of rainfall recharge and recharge from other sources like canal/drain seepage, return flow from irrigation, seepage from domestic water supply and recharge from water conservation structure. The Annual Groundwater Recharge for NCT Delhi 2020 is estimated as 31811.76 ham. Assessment unit wise details of estimation is presented in Table 16 (column 4 to 6).

7.4.2 Annual Extractable Groundwater Recharge

The annual extractable groundwater recharge as defined in GEC 2015 methodology, involving component of monsoon & non-monsoon recharge and excluding component for natural discharge for the environment, following GEC 2015 norms has been estimated for NCT Delhi is 28630.55 ham. Assessment unit wise details of estimation is presented in Table 16 (column 8).

7.4.3 Annual Groundwater Extraction

During the year under report, almost all departments & Institutions of NCT Delhi have provided geo-referenced extraction data which has been further distributed over Tehsil layer by CGWB to find out tehsil wise extraction. The running hour and discharge have been averaging out as demand of Software. Industrial extraction data was not provided and have been considered on pro rata basis.

The total ground water extraction as defined in GEC 2015 methodology, involving component of domestic ground water extraction, irrigation extraction and industrial

extraction has been estimated for NCT Delhi is 29032.77 ham. Assessment unit wise details of ground water extraction is presented in Table 16 (Column 9 to 12).

7.5 Stage of Groundwater Extraction and Categorization of Assessment Units

The Stage of Ground Water Extraction as on 2020 in NCT Delhi varies from 63% in Nazul land to 130% in Delhi Cantonment. The overall Stage of Groundwater Extraction in NCT Delhi as on 2020 is 101%. The information on Stage of Ground Water Extraction is given in table 16 (column 15).

As per recommendation of GEC 2015 methodology, the Dynamic Groundwater Resources (fresh quality) be planned for future ground water management. Out of 34 new assessment units of NCT Delhi, 3 are categorized as *'Safe'*, 7 as *'Semi Critical'*, 7 as *'Critical'* and rest 17 as *'Over Exploited'*. A summarized data on categorization all 34 assessment units of NCT Delhi is presented in Table 16 (column 16). A map showing categorization of assessment units (Tehsils of NCT Delhi) is presented in Figure 18.

7.6 Annual Allocation for Domestic use and Net Ground Water Availability for future use

Annual Allocation for Domestic use for 2025 has been estimated as 18708.75 ham, for entire NCT Delhi. The Assessment unit wise Annual Allocation for Domestic Use as on 2025 is presented in Table 16, column 13. The Net Ground Water Availability for future use in NCT Delhi is 2164.99 ham (Table 16, column 14).

Figure: 18

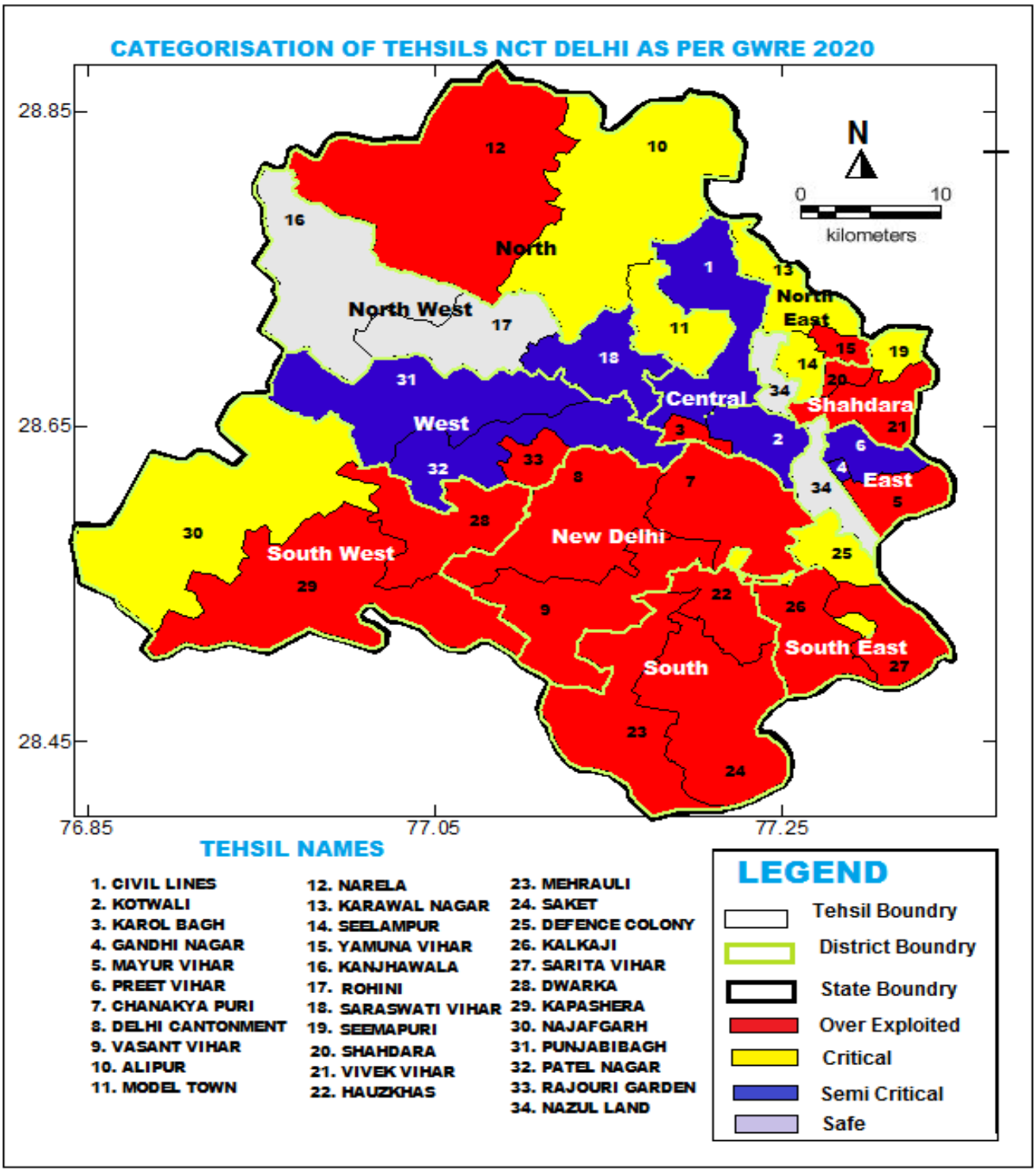

CATEGORISATION OF TEHSILS NCT DELHI AS PER GWRE 2020
28.85
28.65
28.45
76.85
77.05
77.25
N
0
10
kilometers
North
North West
North East
West
Central
Shahdara
East
New Delhi
South West
South
South East
TEHSIL NAMES
1. CIVIL LINES
2. KOTWALI
3. KAROL BAGH
4. GANDHI NAGAR
5. MAYUR VIHAR
6. PREET VIHAR
7. CHANAKYA PURI
8. DELHI CANTONMENT
9. VASANT VIHAR
10. ALIPUR
11. MODEL TOWN
12. NARELA
13. KARAWAL NAGAR
14. SEELAMPUR
15. YAMUNA VIHAR
16. KANJHAWALA
17. ROHINI
18. SARASWATI VIHAR
19. SEEMAPURI
20. SHAHDARA
21. VIVEK VIHAR
22. HAUZKHAS
23. MEHRAULI
24. SAKET
25. DEFENCE COLONY
26. KALKAJI
27. SARITA VIHAR
28. DWARKA
29. KAPASHERA
30. NAJAFGARH
31. PUNJABIBAGH
32. PATEL NAGAR
33. RAJOURI GARDEN
34. NAZUL LAND
LEGEND
Tehsil Boundry
District Boundry
State Boundry
Over Exploited
Critical
Semi Critical
Safe

Table 16: Dynamic Groundwater Resources Estimation 2020, NCT Delhi (Fresh Component)

S.No	District	Assessment Unit	Ground Water Recharge			Total Natural Discharge	Annual Extractable Ground Water Resource (ham) (6-7)	Annual Ground Water Extraction (ham)				Annual GW Allocation for Domestic Use as on 2025 (ham)	Net Annual Ground Water Availability for future use (ham)	Stage of Ground Water Extraction (%) (12/8) * 100	Category	Quality Tagging (if any) As/F/Salinity
			Recharge from rainfall	Recharge from other sources	Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total (9+10+11)					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	Central	Civil Lines Tehsil	127.03	898.79	1025.82	102.58	923.24	136.08	0.00	565.63	701.71	576.58	210.57	76.01	Semi Critical	
2	Central	Karol Bagh Tehsil	14.65	663.57	678.22	67.82	610.40	12.00	0.00	708.87	720.87	744.35	0.00	118.10	Over Exploited	
3	Central	Kotwali Tehsil	66.52	236.00	302.52	30.25	272.27	19.01	0.00	209.42	228.43	213.30	39.96	83.90	Semi Critical	
4	East	Gandhi Nagar Tehsil	5.83	323.79	329.62	32.96	296.66	6.48	0.00	238.80	245.28	238.80	51.38	82.68	Semi Critical	
5	East	Mayur Vihar Tehsil	70.30	529.28	599.58	59.96	539.62	80.36	0.00	497.67	578.03	515.69	0.00	107.12	Over Exploited	
6	East	Preet Vihar Tehsil	56.33	572.31	628.64	62.86	565.78	41.85	0.00	386.01	427.86	397.38	126.54	75.62	Semi Critical	
7	New Delhi	Chanakyapuri Tehsil	142.57	247.00	389.57	38.96	350.62	235.20	0.00	213.09	448.29	217.36	0.00	127.86	Over Exploited	
8	New Delhi	Delhi Cantonment Tehsil	222.86	772.49	995.35	99.53	895.81	119.59	0.00	1045.38	1164.98	1067.15	0.00	130.05	Over Exploited	Salinity
9	New Delhi	Vasant Vihar Tehsil	77.50	843.48	920.98	92.10	828.89	122.23	0.00	944.31	1066.54	1011.21	0.00	128.67	Over Exploited	Salinity
10	North	Alipur Tehsil	450.35	1727.12	2177.47	217.75	1959.72	141.34	1560.00	217.27	1918.60	221.26	37.12	97.90	Critical	Salinity
11	North	Model Town Tehsil	114.61	499.13	613.74	61.37	552.37	88.40	0.00	455.74	544.14	472.70	8.24	98.51	Critical	Salinity
12	North	Narela Tehsil	618.63	1738.48	2357.11	235.71	2121.40	33.63	1944.00	536.58	2514.20	547.86	0.00	118.52	Over Exploited	Salinity
13	North East	Karawal Nagar Tehsil	72.22	322.49	394.71	39.47	355.24	76.50	0.00	274.10	350.60	279.68	4.63	98.69	Critical	
14	North East	Seelampur Tehsil	44.50	565.01	609.51	60.95	548.56	15.19	0.00	529.37	544.56	531.22	2.15	99.27	Critical	
15	North East	Yamuna Vihar Tehsil	23.36	167.16	190.52	19.05	171.47	13.48	0.00	202.05	215.52	213.92	0.00	125.69	Over Exploited	
16	North West	Kanjhawala Tehsil	399.33	1844.96	2244.29	224.43	2019.86	306.56	0.00	1034.98	1341.54	1034.98	678.32	66.42	Safe	Salinity
17	North West	Rohini Tehsil	171.78	668.48	840.26	84.03	756.23	35.44	0.00	485.14	520.57	511.67	209.11	68.84	Safe	
18	North West	Saraswati Vihar Tehsil	163.87	444.88	608.75	60.88	547.88	156.75	0.00	309.31	466.06	331.38	59.75	85.07	Semi Critical	Salinity
19	Shahdara	Seemapuri Tehsil	30.36	510.11	540.47	54.05	486.42	51.84	0.00	428.21	480.05	428.21	6.36	98.69	Critical	
20	Shahdara	Shahdara Tehsil	20.55	412.70	433.25	43.33	389.93	9.07	0.00	452.10	461.17	468.25	0.00	118.27	Over Exploited	
21	Shahdara	Vivek Vihar Tehsil	111.47	404.09	515.56	51.56	464.00	178.20	0.00	333.41	511.61	353.02	0.00	110.26	Over Exploited	
22	South	Hauz Khas Tehsil	70.66	376.12	446.78	44.68	402.10	66.42	0.00	448.57	514.99	457.76	0.00	128.07	Over Exploited	
23	South	Mehrauli Tehsil	82.86	767.49	850.35	85.03	765.31	35.42	0.00	947.38	982.80	963.76	0.00	128.42	Over Exploited	
24	South	Saket Tehsil	97.50	1318.59	1416.09	141.61	1274.48	140.40	0.00	1282.10	1422.50	1310.14	0.00	111.61	Over Exploited	
25	South East	Defence Colony Tehsil	195.62	585.19	780.81	78.08	702.73	105.12	0.00	561.00	666.12	561.00	36.60	94.79	Critical	
26	South East	Kalkaji Tehsil	97.01	332.13	429.14	42.91	386.23	81.71	0.00	358.02	439.73	399.04	0.00	113.85	Over Exploited	
27	South East	Sarita Vihar Tehsil	150.02	371.71	521.73	52.17	469.56	56.16	156.00	324.23	536.39	330.41	0.00	114.23	Over Exploited	
28	South West	Dwarka Tehsil	336.99	526.81	863.80	86.38	777.42	472.50	0.00	530.56	1003.06	567.53	0.00	129.02	Over Exploited	Salinity
29	South West	Kapashera Tehsil	540.40	1770.10	2310.50	231.05	2079.45	1725.36	0.00	780.87	2506.23	821.21	0.00	120.52	Over Exploited	Salinity
30	South West	Najafgarh Tehsil	638.46	2284.81	2923.27	292.33	2630.94	1713.60	0.00	764.21	2477.81	777.59	139.75	94.18	Critical	Salinity
31	West	Patel Nagar Tehsil	110.92	1236.15	1347.07	134.71	1212.36	104.76	0.00	906.94	1011.70	906.94	200.66	83.45	Semi Critical	Salinity
32	West	Punjabi Bagh Tehsil	365.60	1225.30	1590.90	159.09	1431.81	495.90	0.00	755.41	1251.31	755.41	180.51	87.39	Semi Critical	Salinity
33	West	Rajouri Garden Tehsil	43.93	372.11	416.04	41.60	374.44	57.89	0.00	418.35	476.24	437.10	0.00	127.19	Over Exploited	Salinity
34	Nazul Land	Nazul Land Tehsil	122.85	396.51	519.36	51.94	467.43	249.20	0.00	44.06	293.26	44.89	173.34	62.74	Safe	
	Total		**5857.44**	**25954.35**	**31811.79**	**3181.18**	**28630.61**	**7183.62**	**3660.00**	**18189.13**	**29032.75**	**18708.75**	**2164.99**	**101.40**	**Over Exploited**	

7.7 Comparison of GWRE 2020 with Previous GWREs of NCT Delhi

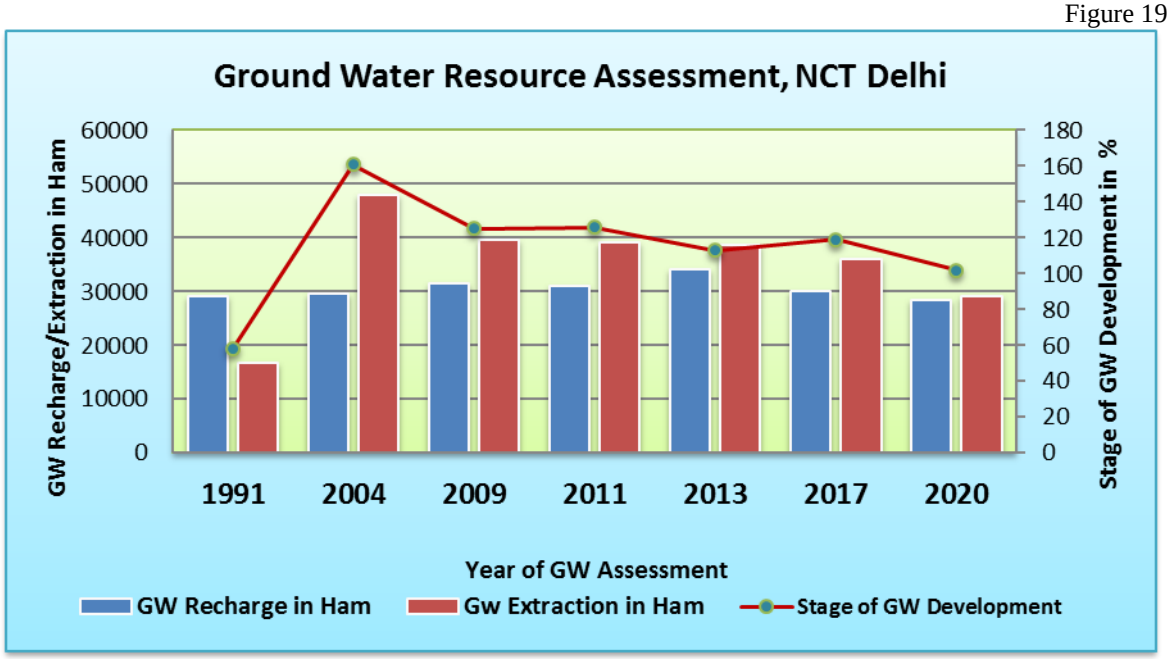
The comparison of GWRE 2020 with the previous estimates of 1991, 2004, 2009, 2011, 2013 and 2017 has been presented in the Table No. 17. shows a decline trend. This is on account of more refined methodology and refined database over the period. From year 2004 onward more refined GEC 1997 methodology was in vogue for next three assessment. Moreover, the database on which computation were carried out was updated continuously. In year 2013, data pertaining to canals / drains were updated which reflected as positive impact on the total ground water recharge. Further, there was reduction in domestic Ground Water Extraction which was attributed to the increased piped (surface) water supply by DJB during the period of assessment. The regulation on drilling of new bore wells in whole NCT Delhi has also contributed to lesser dependency on ground water and all these factors led of slight lower development compared to previous two estimates.

Comparison of present GWRE 2020 with earlier estimates is presented in Table 17 and Figure 19.

Table 17: Comparison of GWREs of NCT Delhi

Methodology	1991	2004	2009	2011	2013	2017	2020
	GEC 1984	GEC 1997				GEC 2015	
Total Annual Recharge (ham)	29154	29710	31501	31050	34192	30090	28490
Total Ground water Extraction (ham)	16840	47945	39619	39215	38785	35990	29032
Stage of Ground water Development (%)	58	161	125	126	113	119	102

Figure 19



(GWRE 2020) estimate. The reduced ground water recharge compared to the earlier estimation can be corroborated with diminishing average annual rainfall over last five years and extreme climate events despite refinement of data pertaining to recharge from water conservation structure. This can further be collaborated with the significant decreasing trend in annual rainfall in NCT Delhi areas, as per analysis of rainfall data study report of IMD[2]. Similarly, reduced ground water extraction compared to the earlier estimate can be attributed less dependency on ground water resources over the period of assessment (2015-19), for drinking water supply in NCT Delhi by implementation / coverage of large additional pockets by piped water supply of DJB. Moreover, increased urbanization also resulted less ground water extraction for agriculture uses. However, overall development status remained around 102 %, i.e., more extraction than annual replenishable recharge, resulting in mining of static ground water resources of the NCT Delhi. This has reflected in decreasing ground water levels in major part of NCT Delhi.

Conclusion and Recommendation

It can be concluded that Dynamic Ground Water Resource of NCT Delhi is improving in certain districts of NCT Delhi because of implementation of interventions suggested by Hon'ble NGT, CGWB, use of treated water for Irrigation, improvement of water supply of Delhi Jal Board and less dependency on groundwater.

It was recommended during 4th & final meeting for approval of Dynamic Groundwater Resource 2020 and during Workshop that Estimation for 2022 may be undertaken by considering wards as smallest assessment units. It is also recommended to consider intense water conservation activities in South & South East districts of NCT, Delhi especially in south of Shahjahan Reserved Forest up to Chattarpur & further south.

As far as geo-referenced data of ground water extraction & water conservation structures is concerned which is most vital input to INGRES for groundwater estimation, all departments of NCT Delhi & Govt. of India, are recommended to maintain meticulous records of ground water extraction & water conservation to be used in GWRE 2022.

Annexure I(a): Minutes of the first meeting of State Groundwater Coordination Committee

Government of National Capital Territory of Delhi
Urban Development Department
9th Floor, Delhi Secretariat
New Delhi-110002

F.No. 16(554)/UD/W/2015/1189–1211 Dated: 21.10.2020

Minutes of the 1st Meeting of State Ground Water Coordination Committee, NCT of Delhi, held on 29.09.2020 for Ground Water Resource Assessment, 2020.

The 1st Meeting of State Ground Water Coordination Committee, NCT of Delhi, for Ground Water Resource Assessment, 2020 was held on 29.09.2020 at 11:00 A.M. in the Department of Urban Development, Govt. of NCT of Delhi under the chairmanship of Shri. A.V. Prem Nath, Joint Secretary, as Additional Chief Secretary (UD) was in another meeting.

After welcoming the participants, Chairman requested Shri S.K Juneja, Head of Office, Central Ground Water Board, State Unit Office Delhi & Member Secretary of the Committee to initiate the Agenda - wise discussions. Shri. Juneja briefed the members about the Ground Water Resource Assessment (GWRA) methodology and informed that as per the last GWRA 2017, presently out of 33 tehsils of NCT of Delhi, 22 tehsils are over exploited, 02 are critical, 07 are semi critical and 03 are under safe category. He also explained to members regarding the necessity to do the present study of GWRA, 2020. Thereafter, he requested Shri Saidul Haq, Scientist 'D' , Hydrogeologist, CGWB to give brief presentation on Ground Water Resource Assessment Methodology. Shri Saidul Haq briefed the committee regarding need to estimate ground water resources. He explained in detail about the concept of Ground Water Estimation Methodology 2015 explaining inflow and outflow and change in storage of an aquifer.

Thereafter, agenda wise discussions were taken into consideration for GWRA, 2020.

Agenda 1.:- Drinking & Domestic Water Demand:-

It is necessary to workout total water demand of NCT of Delhi. The Delhi Jal Board being nodal water supply agency has been requested to workout tehsil wise water demand of NCT of Delhi. Similarly, Delhi Cantonment Board , MES, NDMC, MCD, PWD, Industries Department, Irrigation & Flood Control Department, have also been requested to estimate and provide data of Water demand to CGWB.

(Action: All Departments of Govt. of Delhi)

Agenda 2.:- Drinking & Domestic Water supply through surface water source (Ganga, Yamuna & Bakhra):-

NCT of Delhi is using water from different sources for Drinking, Domestic, Irrigation, Industrial & Commercials purposes. This has to be identified and quantified. Data for usage of surface water source like Ganga, Yamuna & Bakhra as on 31 March, 2020 is to be provided by DJB. The DJB representative pointed out that DJB does not maintain Tehsil - wise water supply records as it is a revenue boundary only. The DJB can provide Chief Engineer Zone wise data to CGWB. The DJB was further requested to provide Shape files of Chief Engineer Zone layer and quantum of water supplied in each zone. The DJB was also requested to provide information regarding status of water supply in percentage i.e. 100% or less for each zone.

The DJB was briefed regarding necessity to retrieve Tehsil wise data because as per said norms, the Tehsil is smallest assessment unit for ground water resource assessment.

(Action: Delhi Jal Board)

Agenda 3.:- Drinking & Domestic Water Supply through Ground Water:-

The Delhi Jal Board informed that DJB have about 4500 tube wells for supplementing water supply in water deficient areas. The Delhi Jal Board has been requested to provide Geo Tagged information regarding tube wells and their running hour/per day and discharge.
Other agencies using ground water as their source have also been requested to provide data in enclosed format.

(Action: All Govt. Departments including MES and Cantonment Board)

Agenda 4.:- Irrigation Water Demand & Supply:-

Irrigation is also an important input which contributes to recharge as return seepage. Where ever groundwater is used for Irrigation, water level depletion may occur. Therefore, to compute water used for irrigation & recharge thereupon, irrigation water requirement and water supply data is to be provided by Irrigation & Flood Control Department of GNCT of Delhi.
Data needs to be provided in format provided by CGWB.

(Action: I& FC Department)

Agenda 5.:- Cropping Pattern (Area sown in Kharif, Rabi & Zayad):-

Almost 30% to 40% of Delhi area is being used for agriculture. All 3 crops are sown viz. Rabi, Kharif and Zayad. Source wise irrigation data is requested to be compiled. Tehsil wise area under different crops is to be compiled and provided to CGWB. There are areas which are using Canal for irrigation and some areas which are using private tube wells.

(Action: Depart of Agriculture Development)

Agenda 6.:- Number of Institutions & Status of Water Supply:-

There are institutions like Schools, Colleges, Universities, Coaching Institutes, Hospitals, Hostels etc. in each tehsil of NCT of Delhi. These institutions are either getting supply from DJB or using their own tube wells for their water demand.

In this regard, it has been decided that worthy Additional Chief Secretary (UD) will be requested to write DO letters to concerned Govt. Departments seeking authentic information about status and source of water supply in schools, colleges & institutes etc

(Action: Urban Development & DJB)

Agenda 7.:- Number & type of Industries and Status of Water Supply:-

There are Industrial areas in different tehsils of Delhi which are getting water from Delhi Jal Board for their use. Others are having their own tube wells. Geo tagged data regarding source wise water usage by Industries is requested to be compiled by Department of Industries & Delhi Jal Board and provided to CGWB.

(Action: Department of Industries & Delhi Jal Board)

It was decided to request CGWB to prepare a draft proforma (Sub Division Wise) seeking information about Industrial Water supply. (Action: CGWB, Delhi)

Agenda 8.:- Horticulture Water Demand & Status of Water Supply:-

Water is being used for irrigating various parks and reserved forest area of NCT Delhi by different government agencies. Some of them are getting treated water from Treatment Plants of DJB and others are using ground water through their own tube wells. The geo tagged information regarding these tube wells is requested to be compiled and provided to CGWB.

(Action: NDMC, MCD, DDA, PWD, CPWD and Department of Forests)

Agenda 9.:- Number of Commercial Establishments (Malls, Shopping Complex, Hotels, Banquet Hall etc) & status of water demand and supply:-

All commercial units in each tehsil is to be geo tagged and their water usage (DJB/own tube well) is to be mapped. Annual water demand and supply to each unit needs to be compiled and provided to CGWB.

(Action: Municipal Bodies & DJB)

Agenda 10.:- Canal, Drain & Water Bodies:-

CANAL-

Irrigation Department informed the committee that no canal water is used for irrigation. However, Tehsil wise area irrigated by canal, if any, will be compiled and provided. I& FC Department was also requested to provide dimension details and maps for canal.

DRAINS-

CGWB briefed regarding contribution of open drains in recharging ground water. Therefore, it is necessary to compile data regarding perennial drain caring effluent and rainwater drains active during monsoon only.

I& FC was requested to provide dimension details of each drain, number of days water remains in each drain and map for drain.

(Action: I&FC Department and Agriculture Department, Govt. of NCT Delhi)

WATER BODIES –

CGWB briefed regarding role of water bodies in inducing recharge to ground water and increasing soil moisture. Geo tagged information regarding water bodies are required to assess recharge contribution by water bodies.

CE 9Water Bodies), DJB informed that DJB can provide data for 175 water bodies and for remaining water bodies data to be provided by the concerned department as per the attached performa.

(Action: DJB, Forest, Revenue , Cantonment, MES etc)

Agenda 11.:- Recharge Structures:-

CGWB briefed the committee regarding role & contribution of recharge structures in adding additional recharge to ground water apart from rainfall. Therefore, it is necessary to know their location, dimension and numbers. Different govt agencies of NCT Delhi have constructed RTRWH structures, Recharge Pit/shaft, Check dams etc. Geo tagged information regarding recharge structures is to be compiled in the attached performa.

(Action: DJB, Municipal bodies, PWD and all other govt. agencies)

Agenda 12.:- Paved & Unpaved Area:-

CGWB briefed the committee that while estimating rainfall infiltration, it is necessary to know Paved and unpaved area because pave area do not contribute to recharge. NCT Delhi being an Urban State, there are Tehsil wherein very less open/green area exist for facilitating rainfall recharge. Tehsil wise area in square kilometer was requested to be compiled under Paved and unpaved category. Paved area will include Roads and Built up area.

(Action: PWD, MCD, NDMC etc)

Agenda 13.:- Forest Area:-

NCT Delhi has huge reserved forest cover which act as air filter and lungs of residents of Delhi. The forest department uses either ground water through their tube wells or treated water through tankers.

As this committee do not have member from Forest Department, the Chairperson has asked to include a member from Forest Department.

While concluding the meeting , it was felt that since District Level Advisory Committees which decide on permissions for tubewells/borewells are operating in Revenue Department, it is expedient to include Divisional Commissioner, Delhi, as Member of the Committee as their inputs will have a barring on the subject of Ground Water Resource Assessment and in this regard, worthy ACS (UD) will be requested to write to Divisional Commissioner, Delhi. it was also decided that the CGWB will prepare a format for data collection required from various departments/agencies.

(Action: UD Department & CGWB, Delhi)

Committee member from NABARD was not present during the 1st meeting.

It was also felt that representatives from DPGS, CPWD, Civil Engineering Department of IIT Delhi and Forest Department may also be called as special invitees in the 2nd meeting proposed to be held in the 2nd week of October 2020.

The meeting ended with vote of thanks to the Chair.

The list of officers who attended the meeting is enclosed as Annexure-'A'.

(Deputy Secretary)
Department of Urban Development
GNCT of Delhi

Annexure- 'A'

List of Participants

S.N	NAME AND DESIG	DEPT.	EMAIL	Mobile no.
1.	S/Sh AV Prem Nath, JS(UD)	UD, GNCTD	avpremnath@gmail.com splsecyud@gmail.com	9999193164/ 23392270
2.	Vijay Singh, SE(RWH/WR)	DJB	sewaterbodiesdjb@gmail.com	9650290958
3.	Rakesh Sahni, CE(WB)	DJB	cewbdjb@gmail.com	9650291200
4.	Sachin Kumar, JE	Delhi Cantt. Board	ceodelhicantt@gmail.com skskumar790@gmail.com	7042491406
5.	V K Malhotra, CE	NDMC	chiefengineervkm@gmail.com	9717787700
6.	S N Bhardwaj, EE	NDMC	ndmcbhardwaj@gmail.com	7290061935
7.	Mukesh Gupta, CE	DSIIDC	deiadsiidc@gmail.com	9996259028
8.	Anil Tyagi, SE	SDMC	se1sdmc@gmail.com	9717788566
9.	Sanjay Saxena, CE	I & FC Deptt.	ceifcd@gmail.com	9868261111
10.	O. P Shriyestox, CE	I&FC Deptt.	ceifcd@gmail.com	9899260883
11.	K. S Jayachandra, MS	Wetland Authority, Delhi	ceodpgsenv.delhli@nic.in	9412057684
12.	Harish Chander, Ex.Engg. (RWH)	DJB	rainwaterharvesting@gmail.com	9650094544
13.	Somvir Arya, Agronomist	Joint Director, (AV), DW Deptt.	jdagridelhi@gmail.com	9868892636
14.	Maj Alowkik Sutar, GE	GE(U) W/S, MES Delhi Cantt.	uwsdcntdz4-mes@nic.in	8269609582
15.	Sanjay Gupta, CE	NDMC		9818884167
16.	Jitendra Kumar, AE	EDMC	celabedmc@gmail.com	
17.	S K Juneja Head of Office	CGWB	oicnd-cgwb@nic.in	9868823472
18.	Saidul Haq	CGWB		
19.	Faisal Abrar	CGWB		

Annexure I(b): Minutes of the Second meeting of State Groundwater Coordination Committee

Sh. Haq / Faisal
SCD AHG 7/1/21

Government of NCT of Delhi
Department of Urban Development
10th Level C-Wing, Delhi Sachivalaya
I.P. Estate, New Delhi – 110002

F.16(554)/UD/W/2015/Vol.-I/ 16-37 Dated:- 01/01/2021

Minutes of the 2nd Meeting of State Ground Water Coordination Committee, NCT Delhi held on 15.12.2020 for Ground Water Resource Assessment, 2020 under Chairpersonship of Special Secretary (UD), Govt. of NCT of Delhi.

The 2nd Meeting of State Ground Water Coordination Committee, NCT Delhi for Ground Water Resource Assessment, 2020 was held on virtual platform on 15.12.2020 at 4.00 P.M. under the Chairpersonship of Special Secretary (UD), Department of Urban Development, Govt. of NCT of Delhi. The list of officer attended the meeting is enclosed as Annexure-'A'.

Shri S.K Juneja, Head of Office, Central Ground Water Board, State Unit Office Delhi & Member Secretary of Committee welcomed all the participants and apologized that earlier meeting proposed on 17th November, 2020 could not be held due to some unavoidable circumstances. He with the permission of the chair, requested Shri Saidul Haq, Scientist 'D', Hydro-geologist, CGWB to give brief presentation on the status of the data received for initiating Ground Water Resource Assessment, 2020.

Thereafter, agenda wise discussions were taken into consideration for GWRA, 2020 –

Agenda 1.:- Domestic Water Supply Data:-

- It was informed to the committee members that DJB has provided geo-referenced ground water extraction data for four different zones headed by respective Chief Engineers of DJB. The provided data is being processed for identifying Tehsil wise distribution.
- It was brought to the notice of DJB that water supply data from the respective surface water treatment plants of NCT, Delhi to different regions of Delhi is still awaited.
- Shri Rakesh Sahni, Chief Engineer (WB), informed that DJB is providing bulk treated waste water to NDMC however breakup of this water from different WTP & STP will be provided.
- Shri Sahni also informed that DJB can provide hard copy of lay out plan of water distribution line which is available with DJB. GSDL has to be contacted for Soft Copy.

Mail Id of GSDL is **secyit@nic.in,** cs.gsdl@nic.in. It was decided that a letter in this regard will be written by Additional Chief Secretary (UD) to GSDL.

(Action: Urban Development Department/DJB)

Agenda 2:-Delhi Cantonment Board has not yet supplied ground water extraction data:-

Delhi Cantonment Board has provided data in pdf format which is incomplete and not easy to process for Tehsil wise extraction of information. It was requested to provide complete data of groundwater extraction for all uses by cantonment board in MS excel format along with Latitude and Longitude.

(Action: Delhi Cantonment Board)

Agenda 3:- DDA/MCD/NDMC - Ground water extraction data in respect of domestic and horticulture use has not been provided yet:-

It was informed that even after repeated requests DDA/MCD (North, South & East)/NDMC have not yet provided ground water extraction data for domestic and horticulture uses.

(Action: DDA/MCD (North, South & East)/NDMC)

Agenda 4.:- Ground water extraction data by Industries, Malls, Institutions, Banquet Halls, Hotels etc. not received from any district of NCT Delhi:-

It was also informed to the committee members that ground water extraction data by Industries, Malls, Institutions, Banquet Halls, Hotels etc. not received from any district of NCT Delhi. Sh. Haq suggested a letter from Department of Urban development may be issued to the respective DMs in this connection.

(Action: Urban Development Department)

Agenda 6.:- Forest Department to provide GIS layer along with ground water extraction data:-

It was informed that even after repeated requests; Forest Deptt. has not yet provided ground water extraction data for green belt development along with GIS Layer of designated forest area of NCT of Delhi. A letter from the Department of Urban Development may be issued to the Forest Deptt.

(Action: Forest Department)

Agenda 7.:- DMRC to provide ground water extraction data and water level data of metro stations:-

The MD, DMRC has been requested twice to provide ground water extraction and water level data for each Metro Station as DMRC has been granted NOC to sink tube well with the condition to share data with CGWB. However, no ground water extraction data has been received till date. It was decided that a letter in this connection on behalf of Govt. of NCT of Delhi to be written to MD, DMRC.

(Action: CGWB, PS, Additional Chief Secretary (UD)

Sh. Juneja requested that the 3rd meeting may be scheduled in person for more clarity in the 2nd week of January, 2021 for which chairperson of the committee has agreed.

The meeting ended with vote of thanks to the Chair.

1/1/21

(VIKAS GOYAL)
DY. SECRETARY (WATER)

F.16(554)/UD/W/2015/Vol.-I/16-37 Dated:- 01/01/2021

1. The Commissioner, Department of Industries, 419, Udyog Sadan, Flatted Factory Area, Patparganj, Delhi – 110092.
2. The Managing Director (IAS), Geospatial Delhi Ltd., Govt. of NCT of Delhi, 3rd Level, "C" Wing, Vikas Bhawan – II, Civil Lines, Delhi – 110054.
3. The Managing Director (IAS), Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Brigade Lane, Barakhamba Lane, New Delhi – 110001.
4. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt. – 110010.
5. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
6. The Member (Engineering), Delhi Development Authority, Vikas Sadan, INA, New Delhi.
7. The Chief Engineer (Civil-I), New Delhi Municipal Council, Palika Kendra, Sansad Marg, New Delhi.
8. The Chief Engineer, Zone – I, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
9. The Chief Engineer, Zone – II, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
10. The Chief Engineer, South Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
11. The Chief Engineer, North Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
12. The Chief Engineer, East Delhi Municipal Corporation, Patparganj Industrial Area, Delhi.
13. The Director, Department of Environment, Govt. of NCT of Delhi, 6th Level, C-Wing, Delhi Secretariat, I.P. Estate, New Delhi – 110002.
14. The Joint Director (Agriculture), Development Department, 11th Level, MSO Building, ITO, New Delhi – 110002.
15. The General Manager, NABARD, NABARD Tower, 24, Rajender Place, New Delhi – 110005.
16. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
17. The Garrison Engineer (Utility), Water Supply, MES, Delhi Cantonment Board, Delhi – 110010.
18. The Office-in-Charge, State Unit Office, Central Ground Water Board, Ministry of Jal Shakti, Department of WR, RD & GR., GoI, West Block – 2, Wing – 3, Sector – 1, R.K. Puram, New Delhi – 110066.

Special Invites:-

1. Representative of Director General, CPWD, Nirman Bhawan, New Delhi.
2. Representative of Chief Executive Officer, DPGS, 6th Level, Delhi Secretariat, New Delhi.
3. Representative of Professor & Head, Department of Civil Engineering, IIT, Delhi, Hauz Khas, Delhi.
4. Representative of Principal Chief Conservator of Forests, Department of Forests and Wildlife, Govt. of NCT of Delhi, A-Block, 2nd Floor, Vikas Bhawan, I.P. Estate, New Delhi.

(VIKAS GOYAL)
DY. SECRETARY (WATER)

Annexure

List of Participants

S.No.	NAME AND DESIG	DEPT.	EMAIL	Mobile no.
1.	Additional Chief secretary	UD, GNCTD	avpremnath@gmail.com splsecyud@gmail.com	9999193164/ 23392270
2.	Vijay Singh, SE(RWH/WR)	DJB	sewaterbodiesdjb@gmail.com	9650290958
3.	Rakesh Sahni, CE(WB)	DJB	cewbdjb@gmail.com	9650291200
4.	Sachin Kumar, JE	Delhi Cantt. Board	ceodelhicantt@gmail.com skskumar790@gmail.com	7042491406
5.	V K Malhotra, CE	NDMC	chiefengineervkm@gmail.com	9717787700
6.	S N Bhardwaj, EE	NDMC	ndmcbhardwaj@gmail.com	7290061935
7.	Mukesh Gupta, CE	DSIIDC	deiadsiidc@gmail.com	9996259028
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9.	Sanjay Saxena, CE	I & FC Deptt.	ceifcd@gmail.com	9868261111
10.	O. P Shriyestox, CE	I&FC Deptt.	ceifcd@gmail.com	9899260883
11.	K. S Jayachandra, MS	Wetland Authority, Delhi	ceodpgsenv.delhli@nic.in	9412057684
12.	Harish Chander, Ex.Engg. (RWH)	DJB	rainwaterharvesting@gmail.com	9650094544
13.	Somvir Arya, Agronomist	Joint Director, (AV), DW Deptt.	jdagridelhi@gmail.com	9868892636
14.	Maj Alowkik Sutar, GE	GE(U) W/S, MES Delhi Cantt.	uwsdcntdz4-mes@nic.in	8269609582
15.	Sanjay Gupta, CE	NDMC		9818884167
16.	Jitendra Kumar, AE	EDMC	celabedmc@gmail.com	
17.	S K Juneja Head of Office	CGWB	oicnd-cgwb@nic.in	9868823472
18.	Saidul Haq	CGWB		
19.	Faisal Abrar	CGWB		

Annexure I(c): Minutes of the third meeting of State Groundwater Coordination Committee

Government of NCT of Delhi
Department of Urban Development
10th Level C-Wing, Delhi Sachivalaya
I.P. Estate, New Delhi – 110002

F.16(554)/UD/W/2015/Vol.-I/324-343 Dated:-26/02/2021

Minutes of the 3rd Meeting of State Ground Water Coordination Committee, NCT Delhi held on 17.02.2021 for Ground Water Resource Assessment, 2020 under the Chairpersonship of Special Secretary (UD), Govt. of NCT of Delhi.

The 3rd Meeting of State Ground Water Coordination Committee, NCT Delhi for Ground Water Resource Assessment, 2020 was held on virtual platform on 17.02.2021 at 3.30 P.M. under the Chairpersonship of the Special Secretary (UD), Department of Urban Development, Govt. of NCT of Delhi.

Shri Rana Chatterjee, Head of Office, Central Ground Water Board, State Unit Office Delhi & Member Secretary of Committee welcomed all the participants with the permission of the Special Secretary (UD). Sh. Rana Chatterjee, Head of Office gave a brief about the present study on Ground Water Resource Assessment, 2020 and its importance for future management and development of ground water resources.

Thereafter, with the permission of the Chair, Shri Saidul Haq, Scientist 'D', CGWB gave a brief presentation on the status of the data received and about the INGRES software on which the present study of Ground Water Resource Assessment, 2020 is being done for the State of Delhi.

Shri Saidul Haq, Scientist 'D' explained about the INGRES software and informed the committee members that all the data on ground water extraction, recharge, rainfall data which was received from the Departments /agencies and CGWB data was analysed and processed in the INGRESS software. However, it was observed that the computation results from this software are not matching with the actual field conditions in few cases. Hence, he requested to Chairman and all the members of the committee to give some more time to refine the assessment so that the estimation matches with the ground truth. Shri Saidul Haq, Scientist 'D' thanked all the members of the committee for sharing the data with CGWB regarding tube wells, rain water harvesting systems etc. installed by them for the present study on Ground Water Resource Assessment, 2020.

The Chairman agreed that the CGWB will again revisit the assessment procedure and submit the revised report to the committee for consideration at the earliest.

The meeting ended with a vote of thanks to the Chair.

The list of officer attended the meeting is enclosed as Annexure-'A'.

(VIKAS GOYAL)
DY. SECRETARY (WATER)

डायरी सं. / Diary No. 1175
दिनांक / Date 08/03/2021
के.भू.ज.दो. / C.G.W.B.

Sh. Saidul Haq

F.16(554)/UD/W/2015/Vol.-I/ 324 – 343 Dated:-26-/01/2021

1. The Commissioner, Department of Industries, 419, Udyog Sadan, Flatted Factory Area, Patparganj, Delhi – 110092.
2. The Managing Director (IAS), Geospatial Delhi Ltd., Govt. of NCT of Delhi, 3rd Level, "C" Wing, Vikas Bhawan – II, Civil Lines, Delhi – 110054.
3. The Managing Director (IAS), Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Brigade Lane, Barakhamba Lane, New Delhi – 110001.
4. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt. – 110010.
5. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
6. The Member (Engineering), Delhi Development Authority, Vikas Sadan, INA, New Delhi.
7. The Chief Engineer (Civil-I), New Delhi Municipal Council, Palika Kendra, Sansad Marg, New Delhi.
8. The Chief Engineer, Zone – I, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
9. The Chief Engineer, Zone – II, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
10. The Chief Engineer, South Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
11. The Chief Engineer, North Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
12. The Chief Engineer, East Delhi Municipal Corporation, Patparganj Industrial Area, Delhi.
13. The Director, Department of Environment, Govt. of NCT of Delhi, 6th Level, C-Wing, Delhi Secretariat, I.P. Estate, New Delhi – 110002.
14. The Joint Director (Agriculture), Development Department, 11th Level, MSO Building, ITO, New Delhi – 110002.
15. The General Manager, NABARD, NABARD Tower, 24, Rajender Place, New Delhi – 110005.
16. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
17. The Garrison Engineer (Utility), Water Supply, MES, Delhi Cantonment Board, Delhi – 110010.
18. The Office-in-Charge, State Unit Office, Central Ground Water Board, Ministry of Jal Shakti, Department of WR, RD & GR., GoI, West Block – 2, Wing – 3, Sector – 1, R.K. Puram, New Delhi – 110066.

Special Invites:-

1. The Principal Secretary, Revenue Department, Govt. of NCT of Delhi, 5-Sham Nath Marg, Delhi – 110054.
2. Representative of Director General, CPWD, Nirman Bhawan, New Delhi.

(VIKAS GOYAL)
DY. SECRETARY (WATER)

Annexure – A

List of Participants

S.N	NAME AND DESIG	DEPT.	EMAIL	Mobile no.
1.	Sh. Subhash Chandra, SS (UD)	UD, GNCTD	splsecyud@gmail.com	23392270
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4.	Sachin Kumar, JE	Delhi Cantt. Board	ceodelhicantt@gmail.com skskumar790@gmail.com	7042491406
5.	V K Malhotra, CE	NDMC	chiefengineervkm@gmail.com	9717787700
6.	S N Bhardwaj, EE	NDMC	ndmcbhardwaj@gmail.com	7290061935
7.	Pijush Banerjee			
8.	Mukesh Gupta, CE	DSIIDC	deiadsiidc@gmail.com	9996259028
9.	Anil Tyagi, SE	SDMC	se1sdmc@gmail.com	9717788566
10.	Sanjay Saxena, CE	I & FC Deptt.	ceifcd@gmail.com	9868261111
11.	O. P Shriyestox, CE	I&FC Deptt.	ceifcd@gmail.com	9899260883
12.	K. S Jayachandra, MS	Wetland Authority, Delhi	ceodpgsenv.delhli@nic.in	9412057684
13.	Harish Chander, Ex.Engg. (RWH)	DJB	rainwaterharvesting@gmail.com	9650094544
14.	Somvir Arya, Agronomist	Joint Director, (AV), DW Deptt.	jdagridelhi@gmail.com	9868892636
15.	Maj Alowkik Sutar, GE	GE(U) W/S, MES Delhi Cantt.	uwsdcntdz4-mes@nic.in	8269609582
16.	Sanjay Gupta, CE	NDMC		9818884167
17.	Jitendra Kumar, AE	EDMC	celabedmc@gmail.com	
18.	Jt. Director, Agriculture, Delhi			
19.	N.P. Singh, DDH, EDMC			
20.	Vimal Kumar Gupta			
21.	Rana Chatterjee, Head of Office	CGWB	oicnd-cgwb@nic.in	9868886246
22.	N. Jyothi kumar, Scientist 'D'	CGWB		
23.	Saidul Haq, Scientist 'D'	CGWB		
24.	Faisal Abrar, AHG	CGWB		
25.	Ashok Kumar, STA (HG)	CGWB		
26.	V. Praveen Kumar, STA (HG)	CGWB		

Annexure I(d): Minutes of the fourth meeting of State Groundwater Coordination Committee

Government of NCT of Delhi
Department of Urban Development
10th Level C-Wing, Delhi Sachivalaya
I.P. Estate, New Delhi – 110002

F.16(554)/UD/W/2015/Vol.-I/669-688 Dated:- 08/04/2021

Minutes of the 4th Meeting of State Ground Water Coordination Committee, NCT Delhi held on 26.03.2021 for Ground Water Resource Assessment, 2020 under the Chairpersonship of Addl. Chief Secretary (UD), Govt. of NCT of Delhi.

The 4th Meeting of State Ground Water Coordination Committee, NCT Delhi for Ground Water Resource Assessment, 2020 was held on virtual platform on 26.03.2021 at 12.30 P.M. under the Chairpersonship of the Addl. Chief Secretary (UD), Department of Urban Development, Govt. of NCT of Delhi.

Shri Rana Chatterjee, Head of Office, Central Ground Water Board, State Unit Office, Delhi & Member Secretary of Committee welcomed all the participants with the permission of the Addl. Chief Secretary (UD). Sh. Rana Chatterjee, Head of Office gave a brief of earlier meetings.

Additional Chief Secretary (UD), in her opening remark highlighted the importance of Ground Water Resources Assessment. It was pointed out that in the last meeting held on dated 17.02.21, it was decided that the Assessment of Ground Water Resources of NCT, Delhi 2020 should be validated with the field conditions and then only the same would be presented for discussion and approval of the State Level Committee. The chairperson enquired whether CGWB has validated the Assessment of 2020 for NCT of Delhi with the field conditions or not. On being replied in affirmative, she advised CGWB to present the Ground Water Resources Estimation 2020 for NCT Delhi (GWRA 2020)and requested the members of the committee to place their observations/ comments on completion of the presentation.

Sh. Rana Chatterjee,Head of Office, CGWB, Delhi presented outline of Ground Water Estimation methodology 2015. He also explained that the methodology has broadly three major components – Assessments of Ground Water Recharge, Assessments of Ground Water Extraction and Computation of Stage of Ground Water Development. He also explained to the committee members that how Categorization of an Assessment unit is done as Safe, Semi Critical, Critical & Over Exploited. He further informed to the committee members that a dedicated software INGRES (India Ground Water Resource Estimation) has been developed by IIT, Hyderabad in collaboration with CGWB. The ground water resource assessment for 2020 for the entire country including NCT, Delhi has been carried out on 'INGRES'.

Sh. Chatterjee profusely thanked all the members of the committee for their cooperation who readily shared the data available with them for the assessment of the Ground Water Resource of NCT, Delhi. This has enabled more realistic for the base year 2020 matching with the ground conditions.

Sh. Chatterjee then requested Shri Saidul Haq, Scientist 'D', CGWB to present the Tehsil wise computation details of Ground Water Resources Assessment of NCT, Delhi and their Category as on March 2020.

Shri Saidul Haq, Scientist D listed out the various agencies who have provided data for assessment of Ground Water Resources of Delhi. He also explained how geo referenced data of Ponds/Tanks, Recharge Structures and Tube Wells have been distributed over Tehsils with the help of IT professionals of NWIC (National Water Informatics Centre). Thereafter, Tehsil wise ground water resources assessment for all 11 districts were presented along with ground conditions like ground water level, quality, sources of water supply, drainage etc. At last, Shri Saidul Haq, Scientist D of CGWB presented following assessment outcome for NCT Delhi:-

Contd...2/-

Total Annual Extractable Ground Water Resources - 28630 hectare meter

Total Annual ground water extraction for all sources - 29000 hectare meter

Stage of Ground Water Development as on March 2020 - 101%.

Out of total 34 Tehsils, 17 are categorized as 'Over-exploited', 7 as 'Critical', 7 as 'Semi-critical' and 3 units are 'Safe'.

Shri Saidul Haq while presenting the GWRA 2020 informed to the committee members that there is a visible change in ground water management & regulation in NCT, Delhi and presented a comparison between 2017 and 2020 assessment.

Improvement in Category of 8 Tehsils of NCT, Delhi is clear indicative of better supply side and demand side management of ground water while deterioration in category of 3 Tehsils indicate need for further management of ground water resource more judiciously. In case of remaining 23 Tehsils, the category remained unchanged though shows some change in stage of ground water development.

On completion of the presentation, the Chairperson of the committee requested the members of the committee to put forward their comments.

Sh. Shalabh Kumar, Member (WS), Delhi Jal Board, opined that the assessment results as put forward in the presentation broadly matches with the field situation and was satisfied with total extraction figure for domestic purpose used in GWRA 2020.

Chief Engineer, North Delhi Municipal Commission remarked that in case of Model Town and Narela, the assessments need to be revisited because there are lots of open areas in both the Tehsil for supporting rainfall recharge.

Chairperson enquired with various members of the committee regarding the ground situation in these two Tehsils. After detailed discussions, it was agreed that the ground water situation matches in case of assessments of Model Town and Narela Tehsils also.

Finally, the State Ground Water Coordination Committee approved the Assessment of Ground Water Resources Assessment, NCT Delhi 2020.

Shri Rana Chatterjee, Head of Office thanked Chairperson of the Committee, Additional Chief Secretary (UD), Govt. of Delhi, all the committee members and participants for their views and participation in the meeting.

The meeting ended with a vote of thanks to the Chair.

The list of officer attended the meeting is enclosed as Annexure-'A'.

(VIKAS GOYAL)
DY. SECRETARY (WATER)

Contd...3/-

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1. The Commissioner, Department of Industries, 419, Udyog Sadan, Flatted Factory Area, Patparganj, Delhi – 110092.
2. The Managing Director (IAS), Geospatial Delhi Ltd., Govt. of NCT of Delhi, 3rd Level, "C" Wing, Vikas Bhawan – II, Civil Lines, Delhi – 110054.
3. The Managing Director (IAS), Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Brigade Lane, Barakhamba Lane, New Delhi – 110001.
4. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt. – 110010.
5. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
6. The Member (Engineering), Delhi Development Authority, Vikas Sadan, INA, New Delhi.
7. The Chief Engineer (Civil-I), New Delhi Municipal Council, Palika Kendra, Sansad Marg, New Delhi.
8. The Chief Engineer, Zone – I, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
9. The Chief Engineer, Zone – II, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
10. The Chief Engineer, South Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
11. The Chief Engineer, North Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi – 110001.
12. The Chief Engineer, East Delhi Municipal Corporation, Patparganj Industrial Area, Delhi.
13. The Director, Department of Environment, Govt. of NCT of Delhi, 6th Level, C-Wing, Delhi Secretariat, I.P. Estate, New Delhi – 110002.
14. The Joint Director (Agriculture), Development Department, 11th Level, MSO Building, ITO, New Delhi – 110002.
15. The General Manager, NABARD, NABARD Tower, 24, Rajender Place, New Delhi – 110005.
16. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
17. The Garrison Engineer (Utility), Water Supply, MES, Delhi Cantonment Board, Delhi – 110010.
18. The Office-in-Charge, State Unit Office, Central Ground Water Board, Ministry of Jal Shakti, Department of WR, RD & GR., GoI, West Block – 2, Wing – 3, Sector – 1, R.K. Puram, New Delhi – 110066.

Special Invites:-

1. The Principal Secretary, Revenue Department, Govt. of NCT of Delhi, 5-Sham Nath Marg, Delhi – 110054.
2. Representative of Director General, CPWD, Nirman Bhawan, New Delhi.

DY. SECRETARY (WATER)

List of Participants

Annexure

S.N	NAME AND DESIG	DEPT.	EMAIL	Mobile no.
1.	Dr. Renu Sharma, Addl Chief Secretary, GNCTD	UD, GNCTD		
2.	Sh. Vikas Goyal, Deputy Secretary (Water), UD, GNCTD	UD, GNCTD	deputysecretarywater@gmail.com	9818039721
3.	Sh. Shalabh Kumar, Member (WS)	DJB	memberwsdjb@gmail.com	9650291441
4.	Sh. Gopal Rai, Chief Engineer	DJB	gopalrai1963@gmail.com	9650699895
5.	Sh. R. K. Ailawadi, Chief Engineer	EDMC		9717788565
6.	Sh. A.P. Saini, Joint Director	Agriculture		
7.	Sh. V K Malhotra, CE	North Delhi Municipal Corporation	vijay.malhotra@mcd.nic.in	9717787700
8.	Sh. Mukesh Gupta, CE	DSIIDC	deiadsiidc@gmail.com	9996259028
9.	Sh. O.P. Shrivastava, Chief Engineer	I & FC Deptt.	ceifcd@gmail.com	
10.	Sh. Anil Tyagi, SE	SDMC	se1sdmc@gmail.com	9717788566
11.	Sh. Sanjay Saxena, CE	I & FC Deptt.	ccifcd@gmail.com	9868261111
12.	Sh. N.P. Singh, DDH	EDMC		
13.	Sh. K. S Jayachandra, MS	Wetland Authority, Delhi	ceodpgsenv.delhli@nic.in	9412057684
14.	Sh. Harish Chander, Ex.Engg. (RWH)	DJB	rainwaterharvesting@gmail.com	9650094544
15.	Maj Alowkik Sutar, GE	GE(U) W/S, MES Delhi Cantt.	uwsdcntdz4-mes@nic.in	8269609582
16.	Sh. Sanjay Gupta, CE	NDMC		9818884167
17.	Sh. R. R. Singh			
18.	Sh. Rana Chatterjee, Head of Office	CGWB	oicnd-cgwb@nic.in	9868886246
19.	Sh. N. Jyothi kumar, Scientist 'D'	CGWB	njyothikumar-cgwb@gov.in	9717449044
20.	Sh. Saidul Haq, Scientist 'D'	CGWB	saidul.haq@gmail.com	7275099349
21.	Sh. Faisal Abrar, AHG	CGWB	fabrar71@gmail.com	9811868445
22.	Sh. S. Ashok Kumar, STA (HG)	CGWB	geologyashok@gmail.com	9642741714
23.	Sh. V. Praveen Kumar, STA (HG)	CGWB	vpraveenaknu@gmail.com	7989093794

Annexure IIa & IIb: Ground Water Level monitoring Pre & Post Monsoon, Average Water Level (2010-19), NCT Delhi

District	Tehsil	Site Name	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		Average WL (2010-2019)
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
NAZUL LAND	NAZUL LAND	Akshardham Temple Pz	4.47	2.3	2.71	3.44	4.44	4.49	4.94	4.52	5.05	5.34	6.77	6.44	6.74	5.6							4.80
CENTRAL	CIVIL LINES	Ashok Vihar IV Pz	10.74	9.85	10.43	10.51	11.53	11.95	12.48	12.12	12.47	13.14	15.43	14.6	15.42	13.82							12.46
SOUTH EAST	KALKAJI	Asola Pz	49.75	44.08	55.45	45.15	48.95	48.85	50.17	47.83	49.72	50.62	51.83	49.84	52.12	47.26	48.64	47.78	51.15	50.25	51.36	51.98	49.64
NORTH	NARELA	Auchandi Pz	4.18	0.53	1.68	1.52	3.51	2.3	3.92	1.11	2.56	3.5	3.02	1.46	3.59	2.5	3.96	2.24	5.10	2.31	1.97	1.78	2.64
NORTH	ALIPUR	Bakoli	10	9.02	8	8.25	8.65	8.74	9.27	8.78	8.68	9.85	9.51	10.35	10.82	11.5	12.02	11.6	13.48	12.74	12.32	12.89	10.32
NORTH	ALIPUR	Bakoli Deep Pz	10.05	9.11	7.97	8.18	8.66	8.82	9.29	8.79	8.7	9.86	9.57	10.58	10.95	11.66	12.13	11.76	13.60	13.03	12.33	13.11	10.41
SOUTH	SAKET	Balbir Nagar DW	26.92	13.2	21	21.32	26.8	20.3	20.4	19.15	22.79	19.77	22.83	16.62	25.04	9.94	28.26	18.24	22.67	17.47	20.25	20.07	20.65
NORTH	NARELA	Bankner Pz	14.16	13.62	15.01	16.2	16.32	16.85	17.97	17.13	16.6	20.63	19.65	20.47	19.54	21.19		22.35	23.80	23.88	23.25	27.56	19.27
WEST	PUNJABI BAGH	Baprola Dw	4.66	1.09	3.5	2.8	4.16	2.82	3.85	2.1	3.76	4.49	5.48	3.12	5.12	3.62	4.35	2.48	3.44	2.16	2.87	2.28	3.41
NORTH	NARELA	Barwala Pz	7.06	4.95	5.25	5.51	5.68	5.86	5.62	5.59	5.38	6.03	6.39	5.44	6.2	5.46	6.01		8.55	6.62	3.84	6.04	5.87
NORTH	NARELA	Bawana DW New	7.08	3.88	5.48	5.68	6.98	6.49	7.57	6.35	6.85	7.16	7.64	6.13	7.27		15.38						7.14
NORTH	NARELA	BBMB Narela	16.86	12.63	14.33	14	15.7	17.21	17.03	16.79	16.98	21.03	18.63	19.17	19.96	21.14	21.5						17.53
NORTH	MODEL TOWN	Bhalaswa Lake Pz	2.93	0.07	1.66	1.1	2.23	1.74	2.23	1.66	1.61	2.16	1.2	0.72	2.33	1.64	2.25	1.62	3.61	3.51			1.90
SOUTH	SAKET	Bhatti Pz	47.31	38.95	45.75	45.15	49.27	43	47.98	44.68	48.07	48.16	49.18	43.01	48.74	47.56	50.61	49.02	50.95	49.61	54.1	53.16	47.71
NEW DELHI	CHANAKYAPURI	Birla Mandir DW	11.45	2.5	6.3	6.9	7.3	9.1	14.86	9.01	13.3	10.78	13.5	11.95	14.9	9.94	11.18		15.46	7.35	10.7	14.83	10.60
CENTRAL	CIVIL LINES	Burari Augur Pz	4.33	1.98	3.13	2.6	3.43	3.44	3.68	2.56	3.14	3.44	3.26	3.41	4.01	2.92	3.76		4.30		3.64		3.35
CENTRAL	CIVIL LINES	Burari Pz	4.52	1.68	3.27	2.36	3.69	3.74	3.98	2.47	3.31	3.66	3.8	3.42	3.51	2.76		2.75	4.30	2.46			3.28
SHAHDARA	SHAHDARA	CBD Shahdara	8.29	7.32	7.7	7.8	8.6	9.07	9.8	8.95	10.42	10.44	10.79	10.27	11	11.17		12.93		14.17	14.7	14.43	10.44
SOUTH WEST	KAPASHERA	Chhawla Pz	17.11	11.87	13.22	13.2	14.12	13.05	14.82	11.94	12.53	14.13	14.74	13.79	15.5	13.35	15.44	14.87	16.25	13.96	14.37	13.3	14.08
EAST	MAYUR VIHAR	Chilla Regulator	8.64	6.85	8	7.3	8.24	7.62	8.19	7.39	8.23	8.71	9.05	8.51	8.92	8.87	9.47	9.85	10.84	11.37	10.6	10.76	8.87
EAST	MAYUR VIHAR	Chilla Saroda Pz	8.92	8.04	8.5	8.41	8.7	8.88	8.95	7.76	8.11	9.2	9.72	9.7	10.04	10.01	10.42			11.66	12.06	11.31	9.47
NEW DELHI	DELHI CANTONMENT	Cvd Depot Cant (Deep)	19.71	18.02	18.3	17.04	19.65	19.06	20.5	19.89		22.06	22.57	22.62	23.94	20.84	26.16	16.1	28.52	28.93		27.55	21.75
SOUTH WEST	NAJAFGARH	Daryapur Khurd	5.67	3.06	4.86	4.55	4.74	4.04	4.49	1.65	4.01	3.98	4.02	3.28	4.28	3.11		3.42		5.12			4.02
SOUTH WEST	KAPASHERA	Daulatpur Pz	18.93	17.1	17.05	16.38	16.89	17.4	16.98	15.42	15.48	15.54	16.85	15.07	16.15	14.24	14.48	14.43	14.47		13.89	13.71	15.81
NORTH	ALIPUR	Delhi College of Enginnerring	6.1	2.63	4.63	3.5	5.27	4.99	5.88	4.54	5.72	6.38	6.82	6.68	7.62	7.82		7.92	8.63	8.77	8.73		6.26
SOUTH WEST	KAPASHERA	Dewarala Pz	2.64	1.44	2.2	1.63	2.4	0.69	2.11	1.51	2.24	1.85	2.14	1.58	2.23	1	1.13	0.32	0.71	1.02	1.07		1.57
SOUTH WEST	DWARKA	Dwarka S-16 (TP)	15.01	14.25	14.8	15.24	16.42	17.62	18.42	18.72	19.48	20.39	21.46	21.88	22.18	22.35	21.92	22.21	23.12	23.7	21.79	21.75	19.64
SOUTH	MEHRAULI	Gadaipur Pz	53.78	53.93	54.3	53.9	56	55.7	56.43	56.9	57.37	58.38	48.55	58.7	58.89	58.63	78.1	60.06	61.18	62.73	62.64	63.15	58.47
EAST	PREET VIHAR	Gazi Pur Crossing	12.95		15.74		17.66	16.89	18.4	17.81	19.68	19.18	21.05	20.27	22.42	21.64	24.05	12.92	24.6	25.26		25.11	19.74
NORTH EAST	YAMUNA VIHAR	Gokulpur E Pz	5.38	5.91	5.03	5.93	6.65	6.85	7.95	7.9	8.73	10.22	11.29	12.01	13.04	12.4	14.43						8.91
NORTH EAST	YAMUNA VIHAR	Gokulpur W Pz	5.3	5.64	5.64	5.69	6.31	6.63	7.71	7.65	8.41	9.97	11.12	11.85	12.89	12.07	14.43						8.75
NORTH	ALIPUR	Haiderpur Pz	10.47	7.46	9	8.39	9.65	9.93	10.27	9.38	9.86	10.84	10.95	10.85	11.38	11.48	12.05	12.14	13.30	13.55	12.88	12.91	10.84
NORTH	NARELA	Hareoli DW	4.4	1.78	5.2	3.19	4.44	4.55	4.58	2.49	3.87	3.41	4.73	2.69	4.74	2.97	4.72	2.45	5.19	2.62	3.5	2.6	3.71
SOUTH	HAUZ KHAS	Hauz Khas Pz	37.37	36.25	34.94	35.07	35.39	35.21	35.15	34.39	33.73	33.97	34.54	34.59	35.03	34.32	33.32	32.81	33.28	33.72	32.14	31.37	34.33
WEST	PUNJABI BAGH	Hiran Kudna DW	2.59	1.34	1.8	1.78	2.91	3	3.53	1.98	2.19	2.88	2.84	1.81	3.33	2.76	3.52	2.47	3.68	2.02	2.78	2.54	2.59
NEW DELHI	CHANAKYAPURI	Humayu Tomb DW	6.8	4.45	5.1	4.6	5.15	5.6	6.4	5.49	6.2	6.93	7.4	7.41	8.17	7.8	8.68	7.91	5.76	11.38	6.69	6.5	6.72
NEW DELHI	CHANAKYAPURI	India Gate Pz	7.49	6.61	7.89	4.79	6.44	6.11	7.46	5.24	5.98	6.88	7.44	8.15	8.04	7.23	8.39	7.44	8.71	8.42	9.78	9.97	7.42
CENTRAL	CIVIL LINES	ISBT (Kasmiri Gate) DW	3.89	1.43	3.2	2.32	2.49	2.38	2.58	2.39	2.56	2.63	2.65	2.74	3.11	2.89	2.41	1.79	3.16	2.17		2.5	2.59
SOUTH WEST	NAJAFGARH	Issapur Khera Pz	11.3	10.33	10.41	10.4	10.71	10.21	10.01	9.73	9.97	10.1	10.3	10.05	10.38	10.11	10.28	10.18					10.28
NEW DELHI	VASANT VIHAR	J N U Pz (Downstream)	30.53	25.93	29.97	29.83	31.74	32	29.7	29.14	27.04	26.84	27.02	23.93	24.66	23.02	20.79	20.43	28.97	23.46	26.88	25.85	26.89
CENTRAL	CIVIL LINES	Jagatpur Pz 1	3.17	1.45	2.52	1.44	2.74	2.34	2.74	1.73	2.3	2.51	2.48	2.22	2.87	2.23	2.5	1.9	4.07	2.4	2.14	2.29	2.40
SOUTH EAST	SARITA VIHAR	Jaitpur Khadar RD3500 Pz	6.08	3.74	3.58	5.15	5.3	5.4	6.6	5.46	6.26	6.38	6.65	6.73	7.52	6.44	6.15					8.12	5.97
SOUTH	MEHRAULI	Jamali Kamali DW	29.6	25.9	29.1	30.1	27.5	29.62	30.2	30.01	27.2	27.65	30.25	28.12	30.49	28.53	26.98	23.62	26.06	22.16	26.1	23	27.61
WEST	PATEL NAGAR	Janakpuri Pz	12.27	11.12	9.42	8.72	9.02	9.32	9.52	9.56	10.47	11.59	12.02	11.77	12.83	11.79	12.94	12.24	13.61	13.21	11.62	11.08	11.21
SOUTH	MEHRAULI	Jaunapur DJB TW	49.13	46.61	46.83	52.05	53.75	54.87	55.15	54.89	58.49	59.63	60.6	55.38	58.84	55.72	55.25	56.55	58.65	57.52	57.81	42.65	54.52
NORTH WEST	KANJHAWALA	Jaunti DW	14.17	12.15	11.92	11.67	12.67	12.58	12.97	11.9	11.84	12.42	12.77	11.82	12.41	11.61	11.85	11.57	15.25	15.2	12.17	12.22	12.56
SOUTH WEST	NAJAFGARH	Jharoda Kalan Pz	16.12	15.1	16.05	14.5	14.8	14.31	14.23	13.77	13.89	14.1	14.56	14.21	14.59	14.13	14.46	14.17	14.74	14.98	14.3	14.19	14.56
SOUTH	MEHRAULI	Jheel Khoh DW	56.4	57.5	53.68	48.55	48.9	49.84	50.02	49.88	50.56	55.09	52.66	49.23	52	49.28	54.13	56.3	65.00	65	64		54.11
SOUTH WEST	NAJAFGARH	Jhuljhuli Dw	2.85	1.97	2.77	2.45	2.75	2.38	2.16	2.13	2.47	2.06	2.2	2.01	2.44	2.21	2.79	2.03	2.20	2.26	2.6	2.13	2.34
NEW DELHI	DELHI CANTONMENT	Kabul Line Pz	26.05	26.27	26.07	25.47	26.24	26.37	26.9	26.23	26.02	26.75	27.17	27.37	27.79	28.39	28.92	29.33	31.12	32.37	31.47	32.07	27.92
NORTH WEST	KANJHAWALA	Kanjhawala Pz	5.6	0.6	1.32	1.14	2.39	1.32	1.97	0.92	1.19	2.8	2.42	1.06	1.85	1.02	1.47	1.29	2.83	1.37	1.48	0.59	1.73
NORTH	ALIPUR	Khera Kalan Pz	6.17	3.23	4.73	3.7	5.41	4.8	6.12	4.05	5.52	5.92	6.9	7.79	8.53	7.97							5.77
NORTH	NARELA	Kingsway Camp Police Ground Pz	6	4.69	4.56	4.13	5.68	5.63	6.64	5.49	6.17	7.29	7.73	7.12	8.55	8.27	9.01	8.86	10.75	10.1	10.13	9.37	7.31
NEW DELHI	DELHI CANTONMENT	Kirbi Place Pz	22.9	21.81	21.69	21.79	23.39	23.59	24.19	23.47	24.69	25.21	26.31	28.54	30.19	27.6							24.67
NEW DELHI	DELHI CANTONMENT	Kitchner Road	19.75	17.5	17.65	19.45	20.25			18.3	17.71	16.41	18.7	16.15	20.71	17.53	26.35						18.96
NEW DELHI	CHANAKYAPURI	Lodhi Garden (D)	11.2	8.49	9.52	9.1	10.3	9.72	10.25	7.82	8.6	8.72	7.92	8.12	9.76	8.55	6.9	7.9	8.30	8.31	7.4	6.92	8.69
NEW DELHI	CHANAKYAPURI	Lodhi Garden.(SH)	11.3	8.28		8.9	10.18	9.75	10.06	7.52	7.9	8.47	7.55	7.8	9.57	8.35	6.72	7.75	8.71	7.85	7.21	6.71	8.45
NEW DELHI	CHANAKYAPURI	Lodhi Graden Dw	14.5	11.99	12.07	12.2	12.92	11.7	13.6	11.49	11.36	12.61	12.1	12.05	12.58	11.9	11.9	11.41	11.58	11.77	6.65	6.63	11.65
SOUTH EAST	SARITA VIHAR	Madanpur Khadar Pz	4.42	2.44	5.3	4.45	4.3	4.39	4.4	3.83	4.59	4.46	4.8	5.22	6.18	5.29	7.05	6.78		7.82	8.06		5.21

District	Tehsil	Site Name	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		Average WL (2010-2019)
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
NEW DELHI	CHANAKYAPURI	Mahabir Vansth.	26.41	24.55	23.25	23.15	24.05	25.05	25.92	25.63	26.97	27.79	27.08	26.83	27.8	27.89	24.65	28.3	29.58	28.38	25.98	27.09	26.32
NORTH WEST	SARASWATI VIHAR	Majara Dabas	5.79	1.22	2.85	2.99	3.91	3.71	3.87	2.62	3.27	3.94	4.01	3.01	3.77	2.52		3.08		3.5	3.32	3.19	3.37
CENTRAL	CIVIL LINES	Majnu Ka Tila DW	8.64	6.84	8.19	10.27	11.54	8.73	10.8	8.61	8.27	8.11	8.17	7.77	9.44	7.95	9.11		11.54	8.34	8.03	7.21	8.82
SOUTH WEST	NAJAFGARH	Mandela Khurd Pz	16.15	13.24	15.09	13.35	14.13	13.23	13.3	11.55	11.71	11.98	12.46	11.85	13	11.41	11.95	11.87	13.24				12.91
NORTH WEST	ROHINI	Mangolpur Pz	5.24	2.48	4.05	3	2.77	2.96	3.4	1.49	2.76	2.71		2.86	2.97	2.76			4.91	3.75	3.32	3.59	3.24
WEST	RAJOURI GARDEN	Mayapuri Pz	33.2	33.7	33.5	34	34.6	34.86	35.54	35.51	35.68	36.63	36.91	36.9	36.76	36.74	37.36	37.76	39.38	38.85	38.7	38.7	36.26
EAST	MAYUR VIHAR	Mayur Vihar B Block Ph II	5.54	6.76	5.34	4.72	6.44	7.44	6.46	6.44	6.69	6.94	7.9	7.84	7.79	7.9	8.27	9.13	8.73	9.15	9.3	9.31	7.40
SOUTH WEST	NAJAFGARH	Najafgarh Town	19.22	16.92	16.18	17.32	18.55	18.98	19.78	18.83	20.16	20.88	21.64	20.66	22.11	21.65	22.47	22.63	22.92	23.66	22.79	22.27	20.48
SOUTHH EAST	DEFENCE COLONY	Nangli Rajapur Pz	3.57	1.78	2.7	2.7	3.6	3.23	3.79	2.29	3.16	3.47	3.99	3.37	4.13	3.21		3.53	4.50	9.75		3.33	3.67
NEW DELHI	CHANAKYAPURI	Nehru Park Dw	24.74	20.7	21.84	22.44	22.74	21.94	22.68	19.05	20.57	22.36	24.12	20.06	24.14	24.08	43.34				43.34		24.88
NORTH WEST	KANJHAWALA	Nizampur EW	13.85	6.58	7.09	7.1	8.03	7.4	7.64	6.57	7.03	7.56	7.95	6.99	7.77	6.36	7.2	6.97	7.29	7.15	7.69	7.84	7.60
NAZUL LAND	NAZUL LAND	Nizamuddin Bridge 1 Pz	4.06	1.13	3.89	3.06	4.06	4.17	4.55	4.15	3.69	4.29	4.73	3.71	4.9	4.07	4.5	3.91	4.59	4.45			4.00
NAZUL LAND	NAZUL LAND	Nizamuddin Bridge 2 Pz	3.49	1.26	3.71	2.78	4.12	3.71	3.24	3.66	4.26	3.82	4.36	4.32	5.09	3.52	4.61	4.54	4.82	5.08		3.77	3.90
SOUTH WEST	NAJAFGARH	Ojwah Pz	19.35	18.39	15.99	14.55	16.42	15.23	15.43	12.57	13.45	14.69	14.84	15.77	15.87	15.08	15.16	15.23		15.8	14.98		15.49
NORTH	ALIPUR	Palla Temple	6.15	3.87	5.48	5.72	5.79	6.04	5.63	5.27	5.29	7	5.98	6.28	7.86	7.29	9.91	7.91	11.64	9.37	9.23	9	7.04
NORTH	ALIPUR	Palla Zero RD	8.6	5.16	6.46	6.23	7.17	7.57	7.64	6.68	6.93	7.81	6.66	8.01	8.63	9.16	9.81	9.92	11.56	11.13	10.83	10.89	8.34
WEST	PUNJABI BAGH	Peeragarhi Pz	7.14	4.6	5.42	4.7	5.2	5.25	5.71	4.16	4.64	5	7.1	4.09	4.78	4.08	4.98	4.53	6.51	6.32	6.12	6.09	5.32
WEST	PATEL NAGAR	PUSA (NRL) Pz	18.06	16.51	16.6	17.1	17.7	18.6	19.17	20.01	20.19	23.11	23.1	24.51	26.6	24.67	28	27.35	28.65	30.36	30.37	30.83	23.07
NEW DELHI	DELHI CANTONMENT	Pusa Institute (WTC)	16.22	16.47	17.1	17.75	18.7	19.6	20.65	19.42	20.32	21.78	22.15	22.44	23.29	23.15	23.8	24.2	26.43				20.79
SOUTH	HAUZ KHAS	Pusp Vihar Pz	66.7	66.84	66.45	66.73	66.2	66.4	66.22	65.81	63.97	63.63	62.22	61.13	58.39	58.09	61.2	54.91	53.60	53.78		49.79	61.69
NORTH	NARELA	Qatlupur Pz	2.68		2.42	1.81	2.74	1.67	2.35	1.32	2.54	2.01	2.64	1.65	3	1.53			4.44	2.05	2.1	1.84	2.28
NORTH WEST	ROHINI	Rani Khera DW	3.49	1.44	2.25	1.8	2.4	3.3	3	2.65	2.58	3.71	3.9	2.22	3.22	1.14	2.36	1.55	3.47	2.15	1.75	0.89	2.46
SOUTH WEST	KAPASHERA	Raota Pz	3.01	2.17	3.51	2.38	2.86	2.3	2.71	1.85	2.69	2.23	2.61	2.26	2.98	2.09	2.8	2.25		2.2	2.81		2.54
NORTH WEST	ROHINI	Rohini Sec 11 Pz	6.07	3.98	5.22	4.6	5.49	6.31	7.06	6.28	6.26	6.37	7.27	5.98	6.54	6.4	7.09	6.8	8.30	7.22	5.5	6.13	6.24
NORTH	ALIPUR	Rohini Sector 28	5.34	2.9	3.49	3.56	4.92	4.6	5.22	3.39	4.43	5.64	5.94	4.84	6.28	5.56	6.5	6.43	7.94	7.94	6.55	6.98	5.42
NEW DELHI	CHANAKYAPURI	Safdarjung tomb	17.25	12.25	13.77	15.85	17.35	16.95	17.95	13.92	14.25	18.01	14.86	16.53	18.77	15.55	16.19	17.15	18.45	16.3	16.75	16	16.21
NORTH WEST	SARASWATI VIHAR	Sainik Vihar Pz	1.68	1.42	2.4	1.8	2.7	1.75	2.81	1.64	2.3	2.02	2.59	2.48	2.92	2.3	3.26	2.81					2.31
SOUTH	SAKET	Satbari Pz	45.5	34.5	39.24	39.15	42.54	42.96	45.2	43.07	45.25	46.6	47.78	45.5	48.42	46.83							43.75
NEW DELHI	DELHI CANTONMENT	Shekhwati Line Pz	40.99	37.99	39.06	38.81	39.59	40.55	40.41	41.48	40.07	40.62	40.45	40.18	41.32	43.26	64.39		47.32	47.53	46.85	45.78	42.98
SOUTH WEST	KAPASHERA	Shikarpur Shallow Pz	16.47	12.15	12.02	11.15	11.85	11.4	12.07	9.66	10.35	11.22	10.68	11.03	11.1	10.57	10.79	10.72	10.52	10.52	10.75	10.04	11.25
NEW DELHI	CHANAKYAPURI	Shram Shakti Bhawan 1	19.1	12.75	13.25	12.45	14.85	15.16	15.38	13.47	13.97	13.83	14.58	12.35	12.13	12.27	13.24	12.49		12.62			13.76
NEW DELHI	CHANAKYAPURI	Shram Shakti Bhawan 3	18.2	14	13.66	13.03	15.01	15.25	15.8	13.4	13.84	14.91	14.97	13.46	14.01	13.76	14.02	12.3	14.00				14.33
NORTH	ALIPUR	Singhola Pz	14.13	10.17	11.58	12.17	13.36	14.14	14.14	14.01	14.11	14.03	14.11	13.99	14.12	14.08	14.08	19.44	21.58	21.51	20.53	21.44	15.34
NEW DELHI	VASANT VIHAR	Sultanpur IMS Pz	48.1	49.6	50.88	49.7	53	53.96	54.33	55.05	55.75	56.48	56.97	57.57	58.12	57.67	59.95	59.81	60.47	61.78	61.4	61.8	56.12
NEW DELHI	CHANAKYAPURI	Sunder Nursery Pz	8.4	6.5	6.96	6.89	7.1	7.45	7.75	6.71	7.25	7.62	7.94	8.08	8.75	7.5	7.9	7.21	8.11	8.15	8.26	7.92	7.62
WEST	RAJOURI GARDEN	Tagore Garden Pz	9.85	6.9	7.69	6.67	7.48	8.75	9.82	9.38	9.93	10.47	11.12	11.5	12.53	11.65	13.45		15.72	15.68	15.21	16	11.04
NORTH	ALIPUR	Tiggipur Deep Pz	7.38	7	7.32	6.63	8.09	7.86	8.32	7.13	8.02	8.81	8.61	8.34	9.21	10.11	10.59	10.3	11.55	10.1	9.66	9.2	8.71
NORTH	ALIPUR	Tiggipur Shallow Pz	9.05	8.44	5.95	5.48	6.37	6.37	6.7	5.82	6.3	6.9	6.78	6.94	7.48	7.87	8.54	7.25	9.74	8.37	8.12	7.92	7.32
WEST	PUNJABI BAGH	Tikri Kalan Pz	9.77	6.87	8.07	7.69	8.28	7.99	8.62	8.21	8.56	8.68	8.8	8.76	8.84	8.79	8.85						8.45
WEST	PUNJABI BAGH	Tilangpur Kotla DW	5.16	3.23	7.17	4.87	5.77	5.07	8.09	5.35	7.36	7.41	7.3	5.52	6.61	5.35	12						6.42
NORTH EAST	SEELAMPUR	Ushmanpur Pz	5.88	0.4	2.46	1.35	2.76	3.8	3.88	2.73	2.89	4.01	4.77	4.68	8.43	4.67	6.02	2.16	6.87	1.95			3.87
WEST	PATEL NAGAR	Vikashpuri Pz	10.03	10.37	10.25	10.85	11.68	12.45	12.78	12.87	14.3	17.24	17.67	16.58	17.24	17.19	15.62	14.77	16.41	15.22	13.17	12.59	13.96
NORTH EAST	KARAWAL NAGAR	Wazirabad RAF	3.7	2.6	3.31	3.04	3.67	3.96	4.45	3.97	4.25	5.04	4.72	5.09	5.44	5.04							4.16

Annexure III: Saline /Fresh ground water depth in NCT Delhi

District	Name of the Assessment Unit	NAQUIM Report		Average Thickness of Hard rock aquifer below SR (up to 100m bgl)	Bottom of unconfined aquifer (in m)(Depth zone below pre-monsoon WL) (For Soft rock upto weathering / muram; Maxfor SR & HR upto 100 m bgl)			
		Pre-monsoon water level (Average of 10 year in mbgl)	Average Tickness of alluvium & Weathred / fractured zones					
1	2	3	4	5	6 A (Fresh) SR	6 B (Saline) SR	6 C (Fresh) HR	6
Central Delhi	Civil Lines	5.24	84	16	34	44	16	94
Central Delhi	Karol Bagh	1.33	59	41	39	19	41	99
Central Delhi	Kotwali	1.68	40	60	38	0	60	98
East Delhi	Gandhi Nagar	9.30	84	16	37	38	16	91
East Delhi	Mayur Vihar	8.44	100	0	36	54	0	90
East Delhi	Preet Vihar	19.01	100	0	34	54	0	88
New Delhi	Chanakyapuri	12.91	53	47	30	13	47	90
		18.93		100	0	0	83	83
New Delhi	Delhi Cantonment	25.25	56	44	15	16	44	75
		26.59		100	0	0	74	74
New Delhi	Vasant Vihar	41.3	80	20	0	29	20	49
		41.3		100	0	0	49	49
North Delhi	Alipur	8.67	100	0	23	69	0	92
North Delhi	Model Town	1.8	87	13	29	56	13	98
North Delhi	Narela	7.99	100	0	22	69	0	91
North East Delhi	Karawal Nagar	4.09	86	14	37	45	14	96
North East Delhi	Seelampur	3.98	86	14	35	45	14	94
North East Delhi	Yamuna Vihar	8.83	86	14	33	45	14	92
North West Delhi	Kanjhawala	7.31	100	0	23	69	0	92
North West Delhi	Rohini	4.04	100	0	26	70	0	96
North West Delhi	Saraswati Vihar	2.85	100	0	28	69	0	97
Shahdara	Seemapuri	10.20	100	0	37	54	0	91
Shahdara	Shahdara	10.20	100	0	37	54	0	91
Shahdara	Vivek Vihar	10.25	100	0	37	54	0	91
South Delhi	Hauz Khas	48.08	72	28	0	27	28	55
		62.53		100	0	0	37	37

Depth Zone Computation for Fresh /Saline Groundwater Resources: Base NAQUIM Data -Column 3 & 4								
District	Name of the Assessment Unit	NAQUIM Report		Average Thickness of Hard rock aquifer below SR (up to 100 m bgl)	Bottom of unconfined aquifer (in m) (Depth zone below premonsoon WL) (For Soft rock upto weathering / muram; Maxfor SR & HR upto 100 m bgl)			
		Pre-monsoon water level (Average of 10 year in m bgl)	Average Thickness of alluvium & Weathered / fractured zones					
1	2	3	4	5	6 A (Fresh) SR	6 B (Saline) SR	6 C (Fresh) HR	6
South Delhi	Mehrauli	48.83	72	28	0	26	28	54
		48.83		100	0	0	53	53
South Delhi	Saket	36.67	72	28	5	29	28	62
		36.67		100	0	0	62	62
South East Delhi	Defence Colony	3.31	64	36	36	24	36	96
		40.00		100	0	0	60	60
South East Delhi	Kalkaji	6.00	64	36	34	24	36	94
		49.51		100	0	0	49	49
South East Delhi	Sarita Vihar	5.49	64	36	35	24	36	95
South West Delhi	Dwarka	19.52	100	0	0	64	0	64
South West Delhi	Kapashera	9.09	100	0	24	67	0	91
South West Delhi	Najafgarh	11.58	100	0	19	67	0	86
West Delhi	Patel Nagar	15.97	100	0	34	52	0	86
West Delhi	Punjabi Bagh	5.03	100	0	42	52	0	94
West Delhi	Rajouri Garden	23.79	54	46	26	6	46	78
Non-Revenue Unit	Nazur Land	4.16	80	20	45	30	20	95

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