Recharge to Over-developed aquifers in Urban Environments of NCT-Delhi, India

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Ex-Incharge, Delhi State, CGWB, MoWR

Profile-NCT Delhi

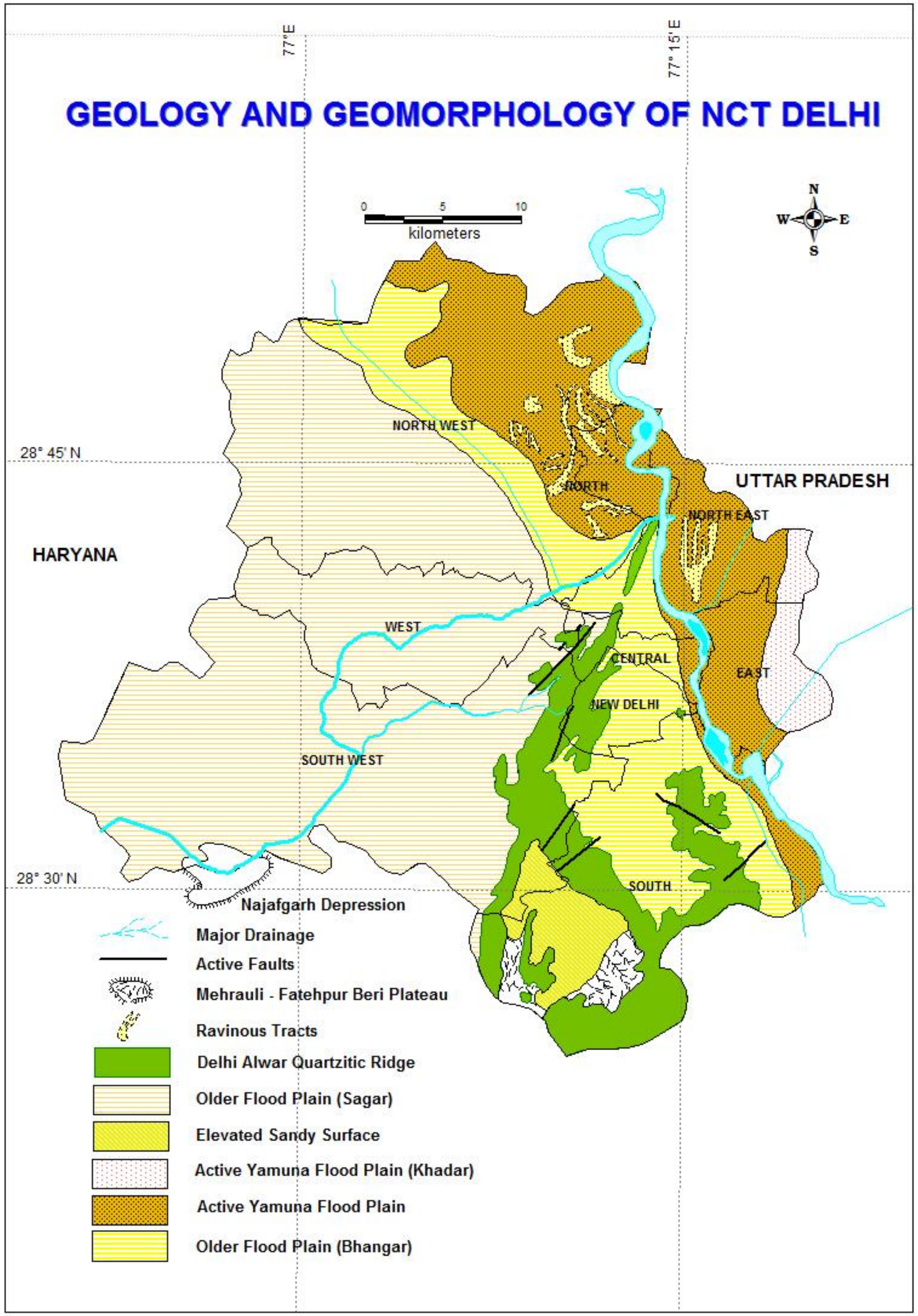
Name of State	**Delhi**
Number of District	**9**
No of Tehsils	**27**
Geographical Area	**1483 Sq.Km.**
Major Geological Formation	**Soft Rock - Younger/Older Alluvium** **Hard Rock – Quartzites**
Major Drainage System	**Yamuna**
Population (as per census 2001) **Population Density**	**138.57 lakhs** **9344 Per Sq.km. area**
Existing Major / Medium Irrigation Projects	**-**
Normal Rainfall	**611.8 mm**
Range of Mean Daily Temperature	**18-32 ^{O}C**

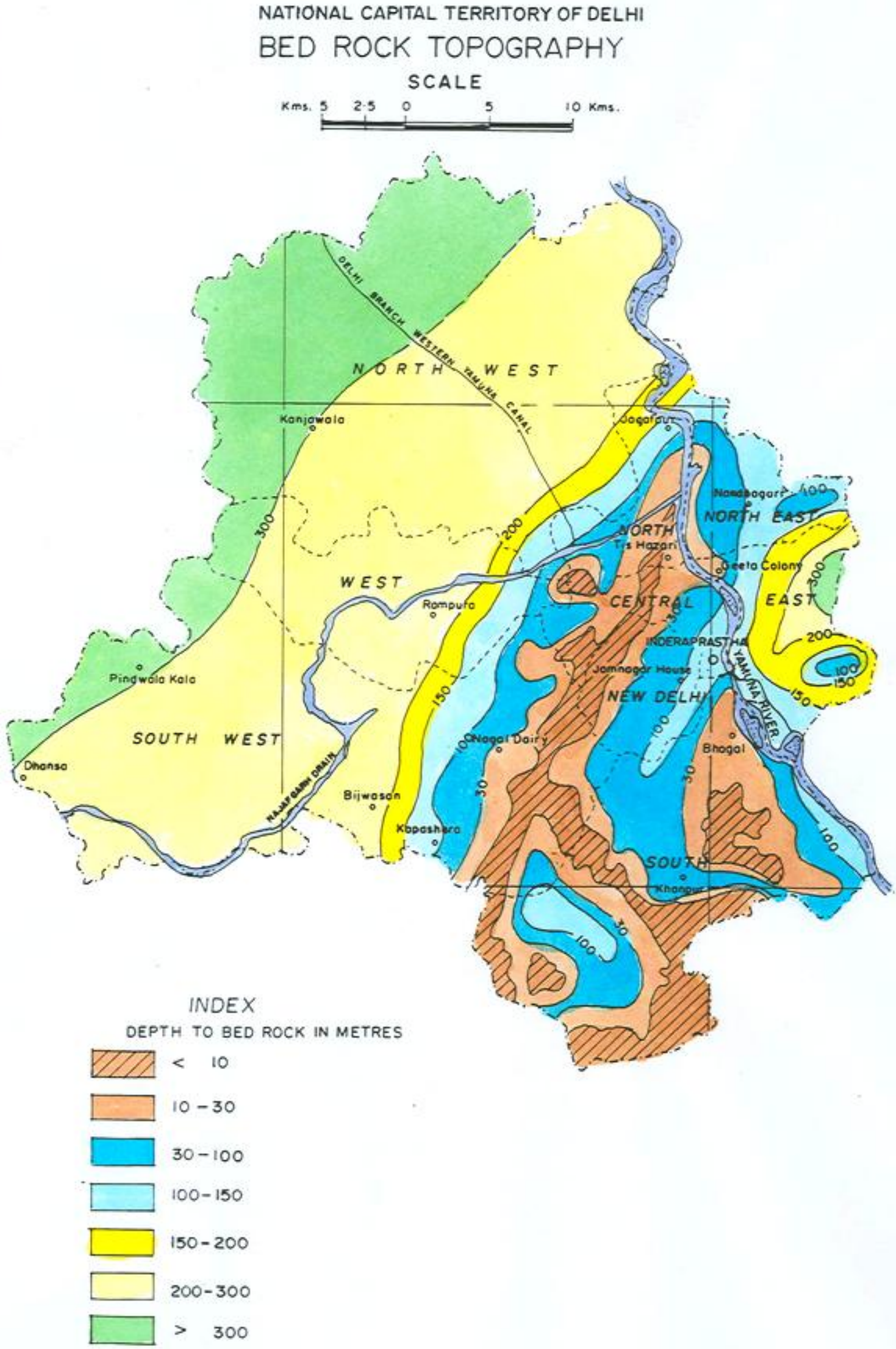
PROJECTED WATER DEMANDS IN NCT, DELHI

	2005		2011		2021	
	Population (In Lakhs)	Water requirement MLD/ (MGD)	Population In Lakhs	Water requirement MLD/ (MGD)	Population In Lakhs	Water requirement MLD/ (MGD)
Drinking and domestic water requirements	163	3675.5 / (808)	205	4612.5/ (1014)	270	6075 / (1355)
Irrigational requirements		200 / (44)		200 / (44)		200 / (44)
Farm house uses		21.5 / (4.7)		21.5 */ (4.7)		21.5 */ (4.7)
Industrial requirements		43 /* (9.5)		43 /* (9.5)		43 /* (9.5)
Total		3940 / (866)		4877 / (1072)		6323 / (1389)

THE FUTURE WATER AVAILABILITY FROM ASSURED SOURCES

Withdrawal of water (MGD)	Source of Water	Treatment Plant
210	Yamuna River	Wazirabad Water Treatment Plant
		Chandrawal Water Treatment Plant
240	Bhakra Storage and Western Yamuna Canal	Hyderpur Water Treatment Plant
		Nangloi Water Treatment Plant
100	Upper Ganga Canal, U.P.	Bhagirathi Water Treatment Plant
140	Water expected from Tehri Dam	Sonia Vihar Treatment plant
20	Surface water	Delhi parallel branch (lining of canal of 102 km stretch)
125	Ground Water	From the tubewells present in different parts of NCT, Delhi and tubewells recommended in Yamuna Flood plain areas (Dewatering and refilling of shallow aquifers)
825		Total


77° E
77° 15' E
GEOLOGY AND GEOMORPHOLOGY OF NCT DELHI
0
5
10
kilometers
N
W
E
S
28° 45' N
28° 30' N
HARYANA
UTTAR PRADESH
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Depression
Major Drainage
Active Faults
Mehrauli - Fatehpur Beri Plateau
Ravinous Tracts
Delhi Alwar Quartzitic Ridge
Older Flood Plain (Sagar)
Elevated Sandy Surface
Active Yamuna Flood Plain (Khadar)
Active Yamuna Flood Plain
Older Flood Plain (Bhangar)

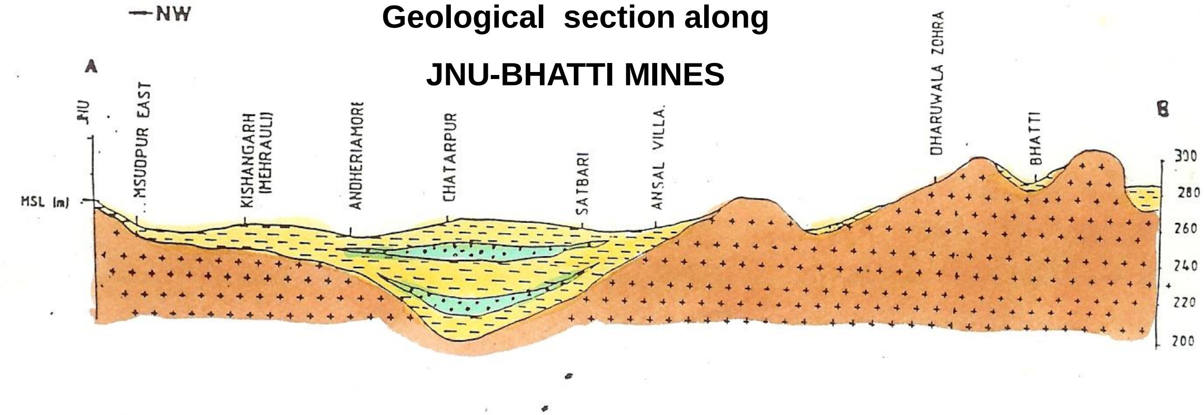


Depth to Bedrock

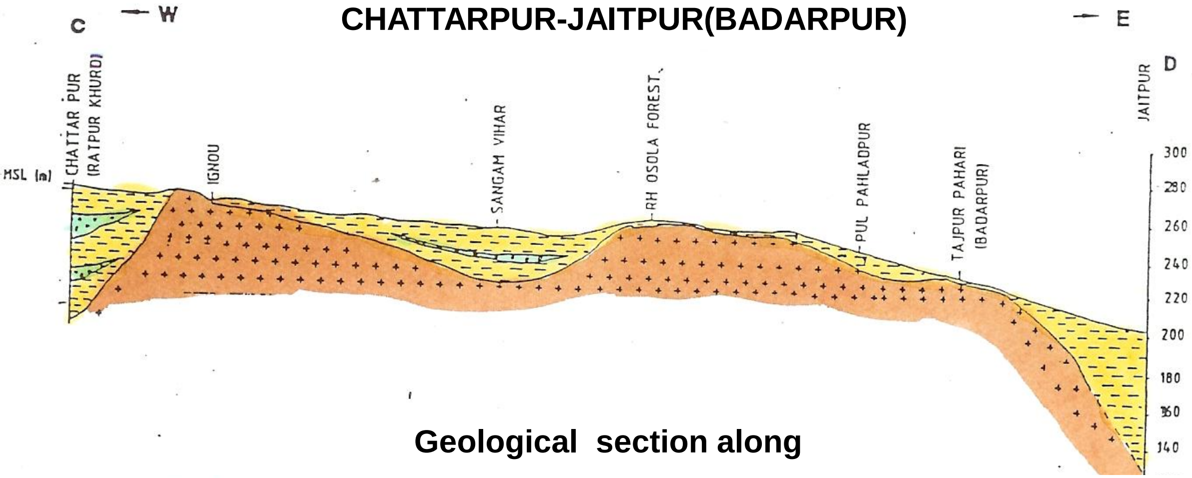
Location	Nature of bed rock	Depth to bed rock in m bgl
RML hospital	Quartzite	35.66
Lady Harding Hospital	Mica schist	42.00
Qudasia garden	Quartzite	23.16
Silver Jubilee Hospital	-do-	145.00
Irwin hospital		22.86
Vikas Bhawan		107.30
Ranbaxy Lab, Okhla		39.01
Yamunaotri, Okhla		27.00
Okhla Industrial area		46.93
West Patel Nagar		63.70
Malaria Instiute		24.38
Swiss Embassy		33.55
Australian high commission		30.48
DTC depot, Vinay Nagar		28.95
I.P. College, Alipur road		25.00

Geological section
South District – NCT Delhi

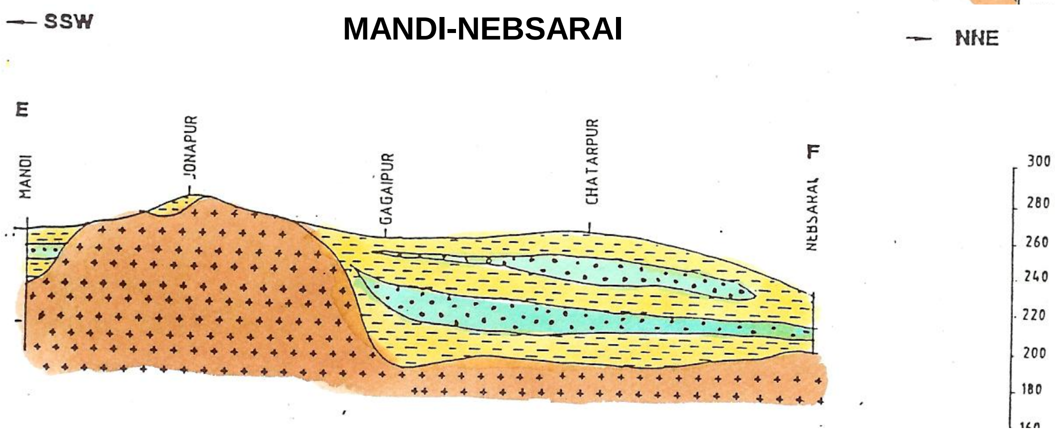
Geological section along
JNU-BHATTI MINES

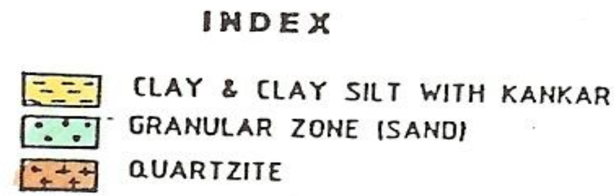


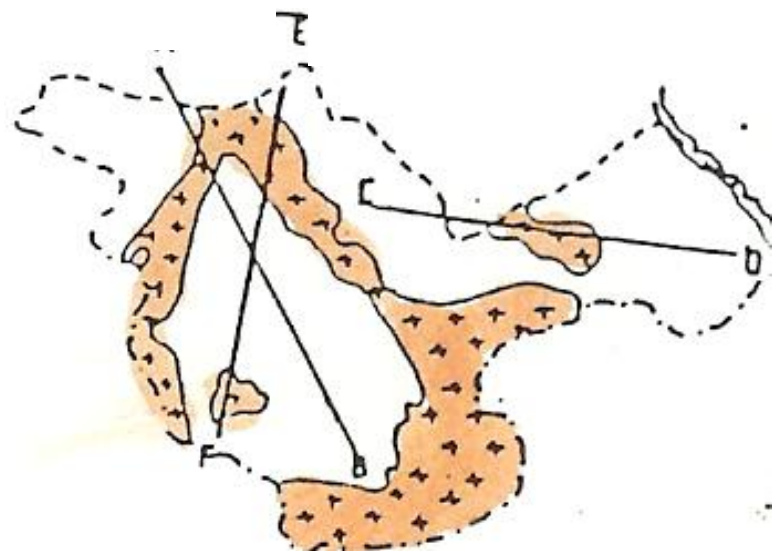
Geological section along
CHATTARPUR-JAITPUR(BADARPUR)



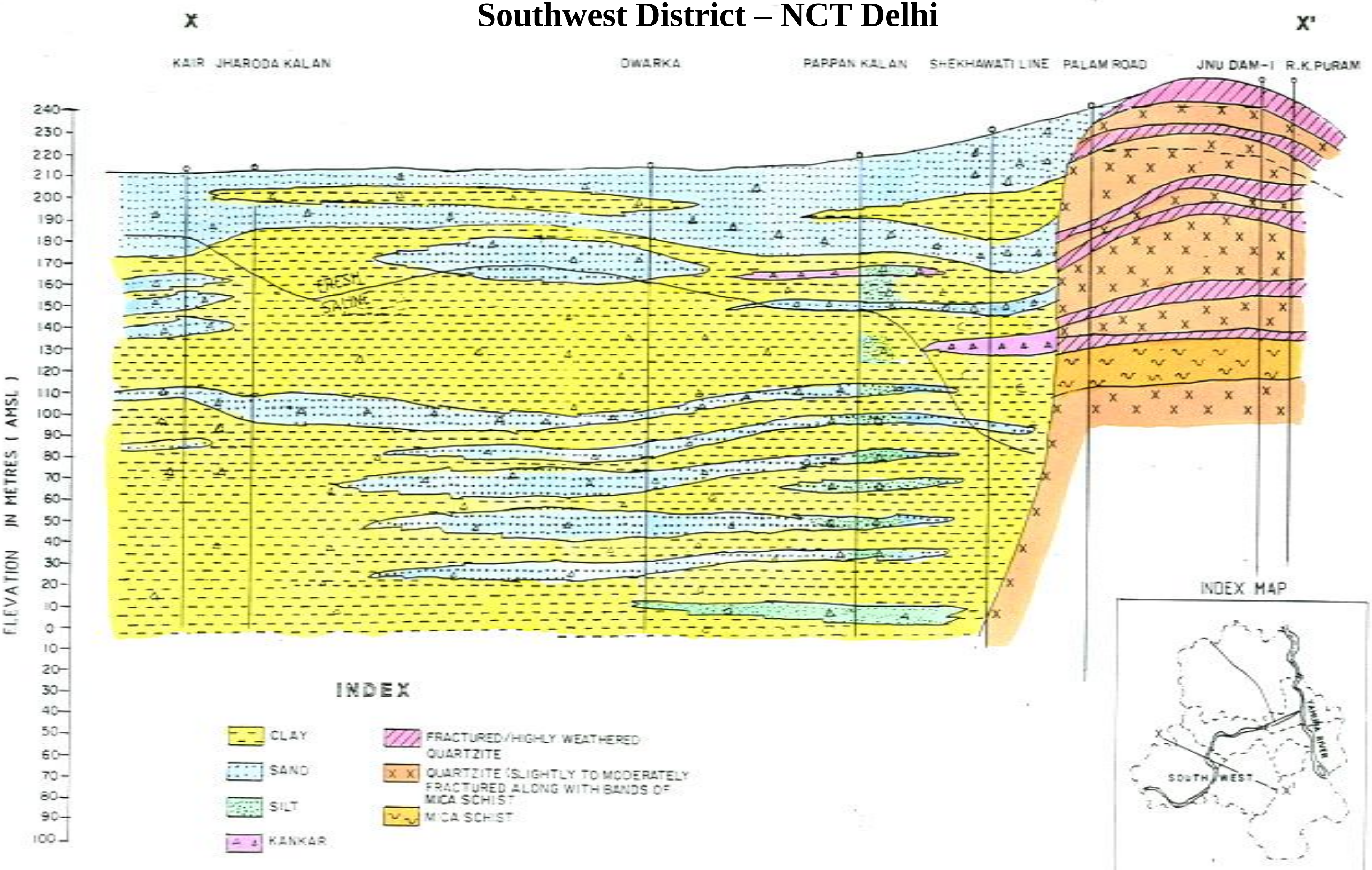
Geological section along
MANDI-NEBSARAI







Subsurface Geological Cross section
Southwest District – NCT Delhi



Rainfall and Evaporation Losses in NCT Delhi

Month	Jan	Feb	Mar	Apr.	May	Jun	July	Aug	Sep	Oct	Nov.	Dec.	Annual
Rainfall (mm)	14.5	13.2	9.9	5.5	9.2	38.8	191.6	197.4	105.3	19.3	2.8	4.3	611.3
Rainy days	1.2	1.0	0.8	0.5	0.8	2.1	7.4	7.9	4.0	0.8	0.1	0.4	27.0
Evaporation (mm)	71	101	177	300	400	333	233	133	147	149	102	78	2224

Source: Indian Meteorological Department

Plate No. -

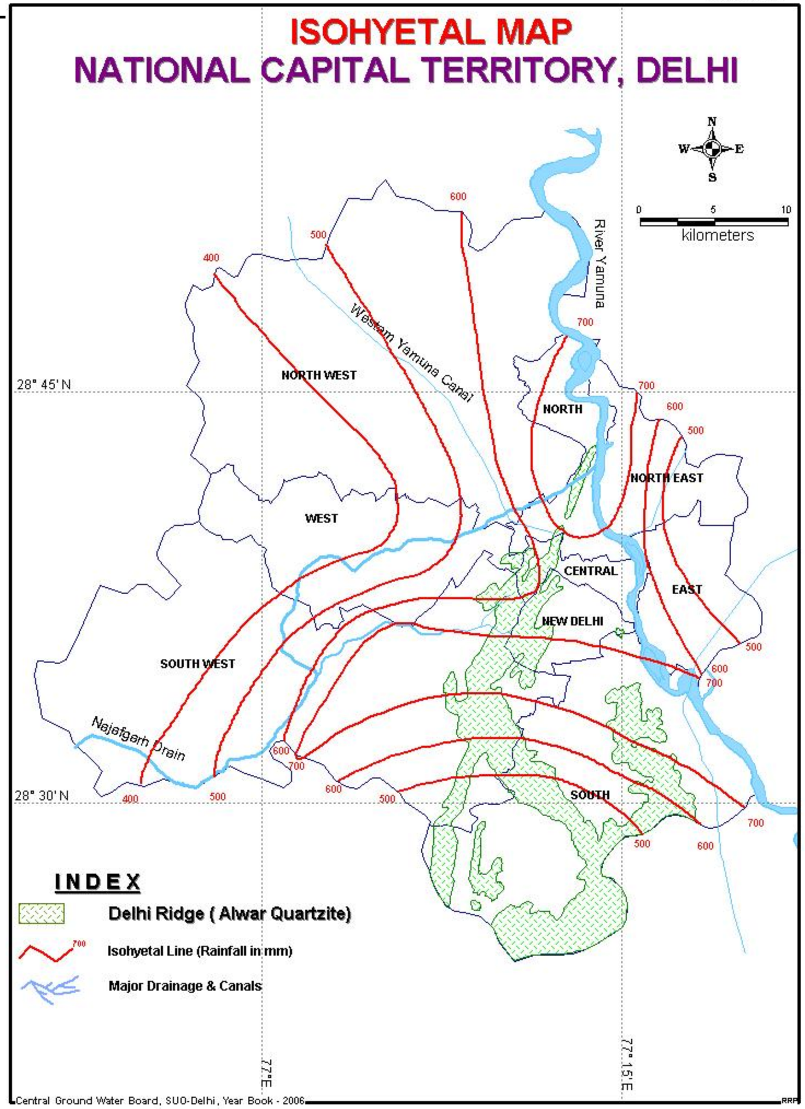
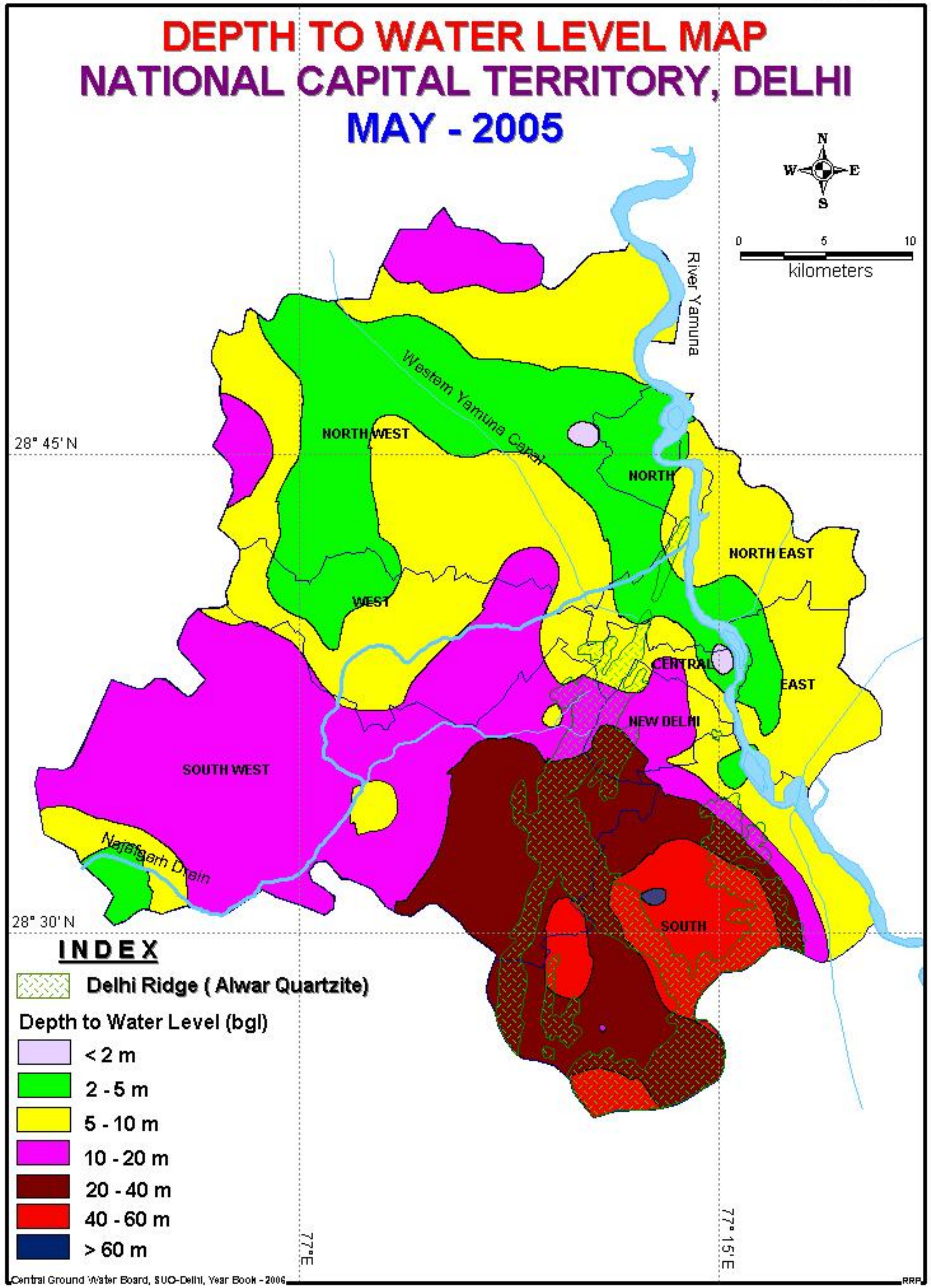
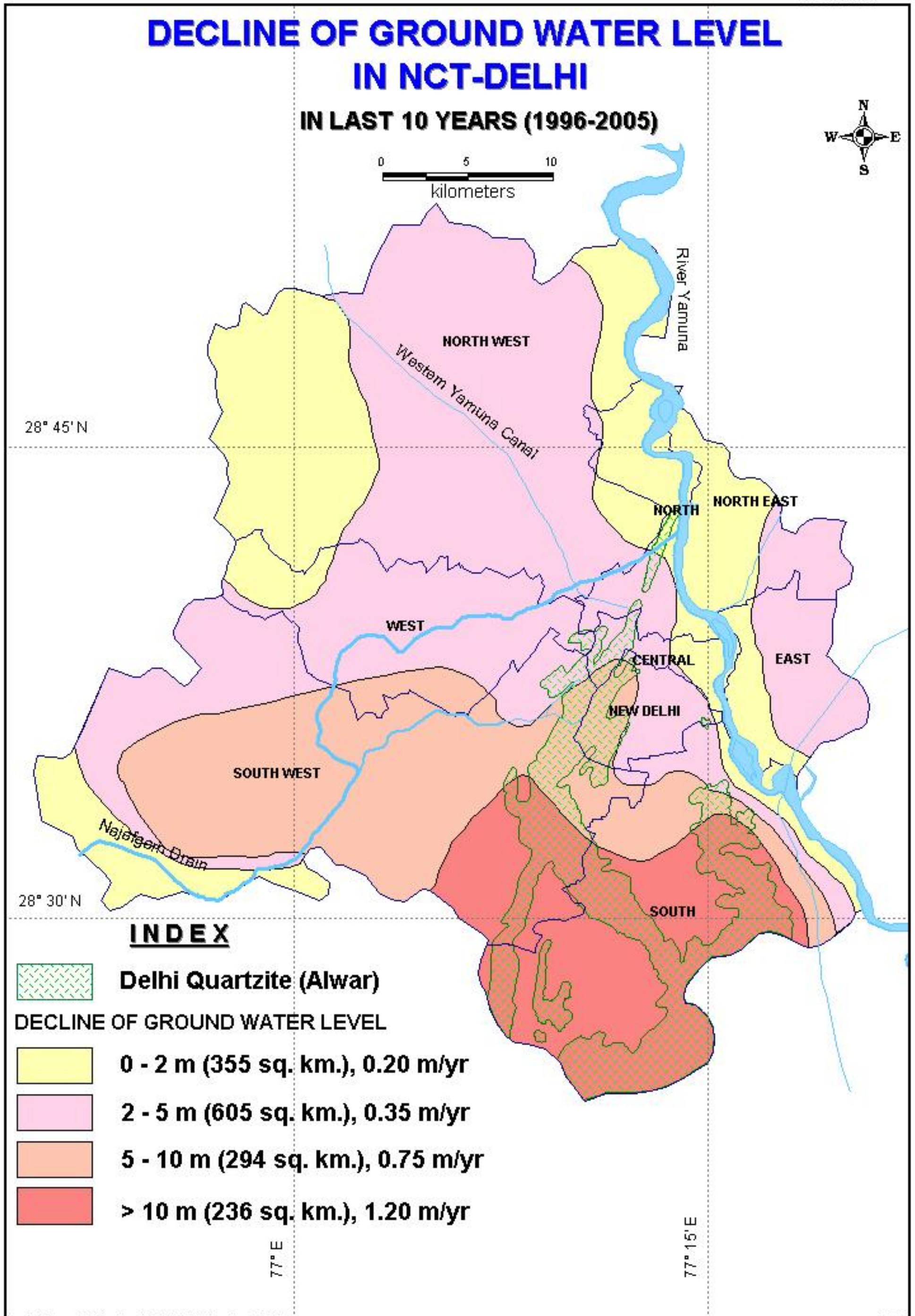
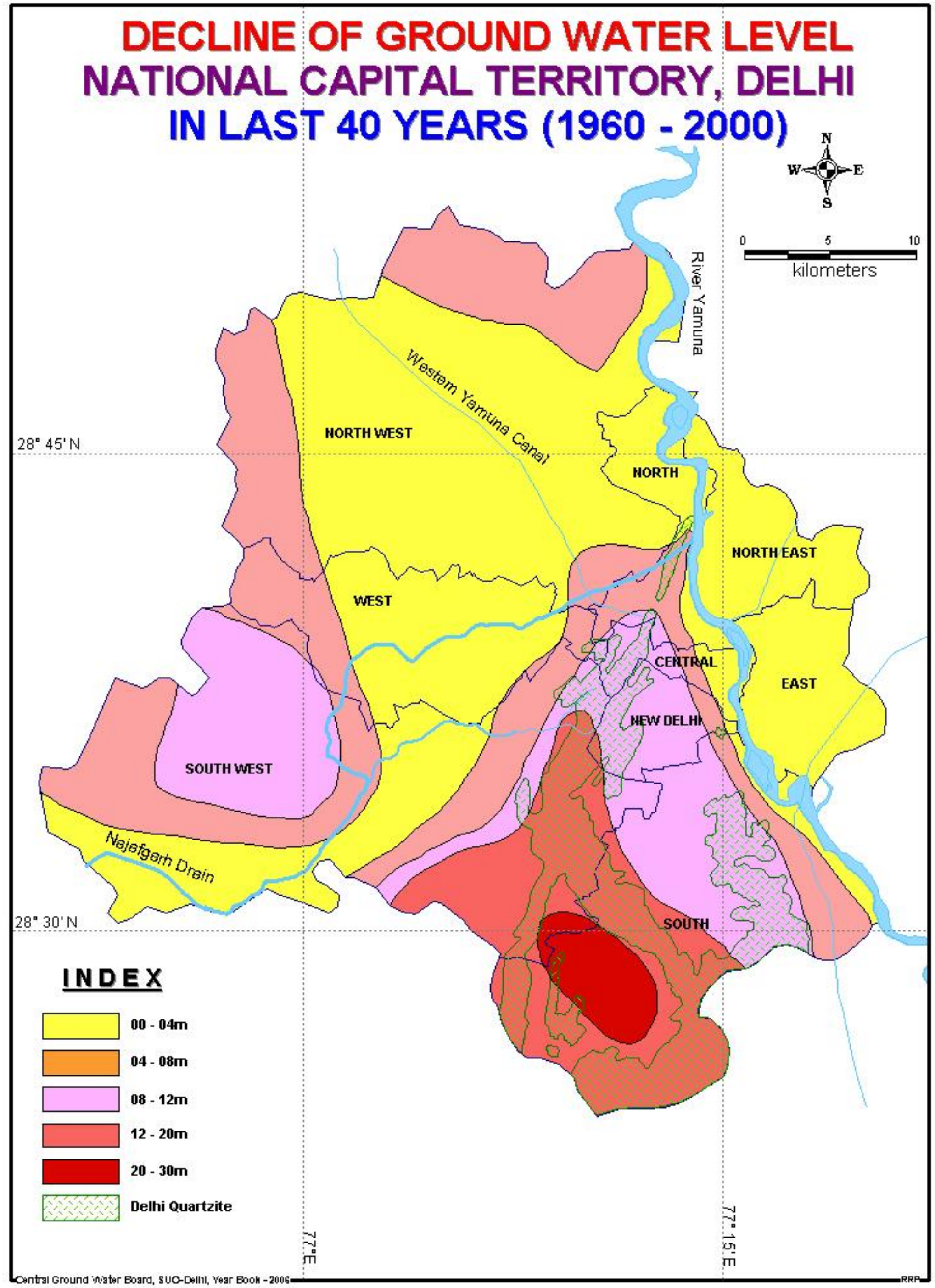


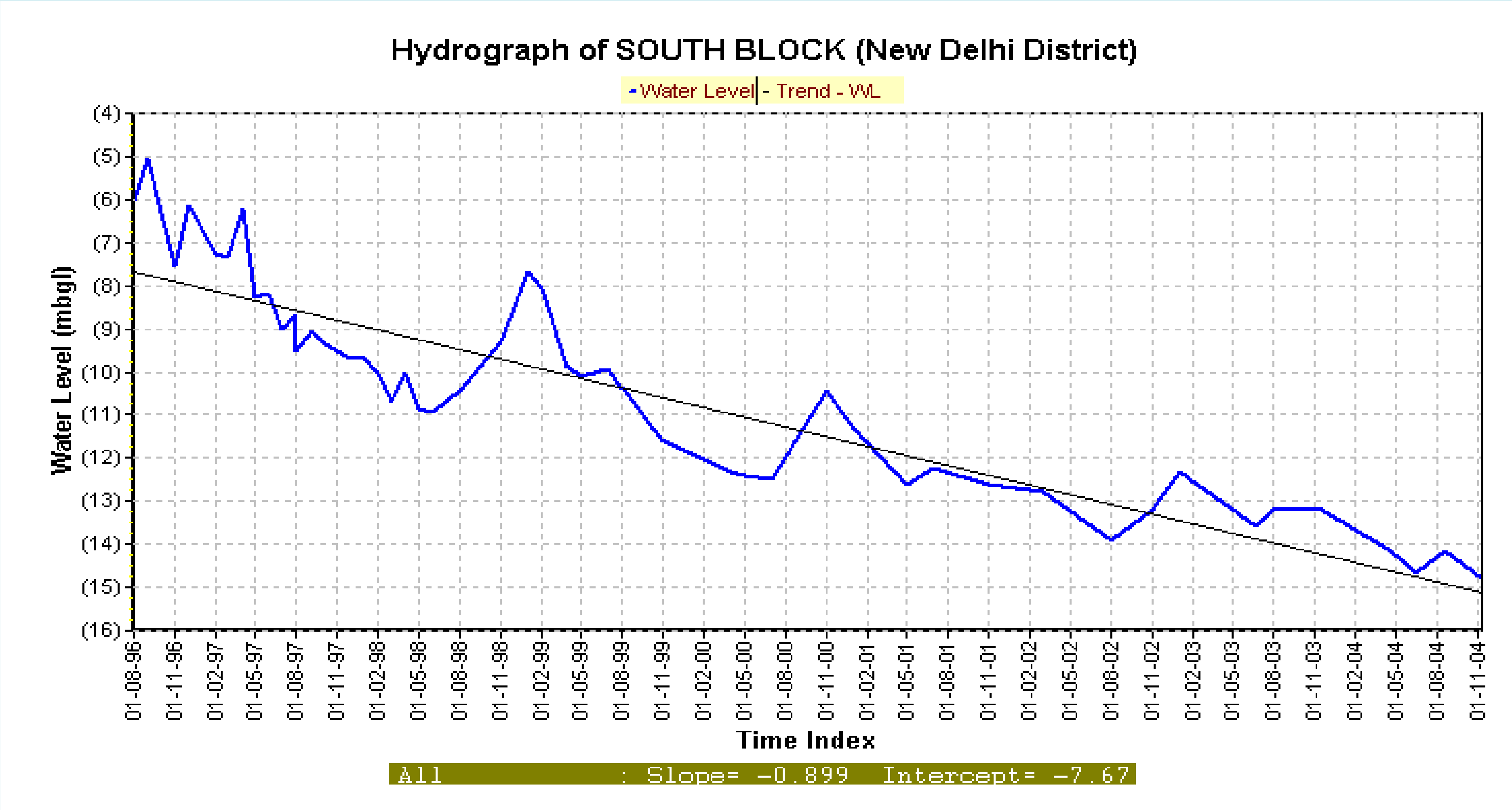
Plate No. -



DEPTH TO WATER LEVEL MAP
NATIONAL CAPITAL TERRITORY, DELHI
MAY - 2005
N
W
E
S
0
5
10
kilometers
River Yamuna
Western Yamuna Canal
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
28° 45' N
28° 30' N
77° E
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Depth to Water Level (bgl)
< 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 40 m
40 - 60 m
> 60 m
Central Ground Water Board, SUO-Delhi, Year Book - 2006


DECLINE OF GROUND WATER LEVEL
IN NCT-DELHI
IN LAST 10 YEARS (1996-2005)
0 5 10
kilometers
N
W
E
S
River Yamuna
NORTH WEST
Western Yamuna Canal
28° 45' N
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
INDEX
Delhi Quartzite (Alwar)
DECLINE OF GROUND WATER LEVEL
0 - 2 m (355 sq. km.), 0.20 m/yr
2 - 5 m (605 sq. km.), 0.35 m/yr
5 - 10 m (294 sq. km.), 0.75 m/yr
> 10 m (236 sq. km.), 1.20 m/yr
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2006
RRP


DECLINE OF GROUND WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
IN LAST 40 YEARS (1960 - 2000)
N
W
E
S
0 5 10
kilometers
River Yamuna
Western Yamuna Canal
NORTH WEST
28° 45' N
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
INDEX
00 - 04m
04 - 08m
08 - 12m
12 - 20m
20 - 30m
Delhi Quartzite
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2006
RRP


Hydrograph of SOUTH BLOCK (New Delhi District)
Water Level
Trend - WL
Water Level (mbgl)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15)
(16)
01-08-96
01-11-96
01-02-97
01-05-97
01-08-97
01-11-97
01-02-98
01-05-98
01-08-98
01-11-98
01-02-99
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01-02-03
01-05-03
01-08-03
01-11-03
01-02-04
01-05-04
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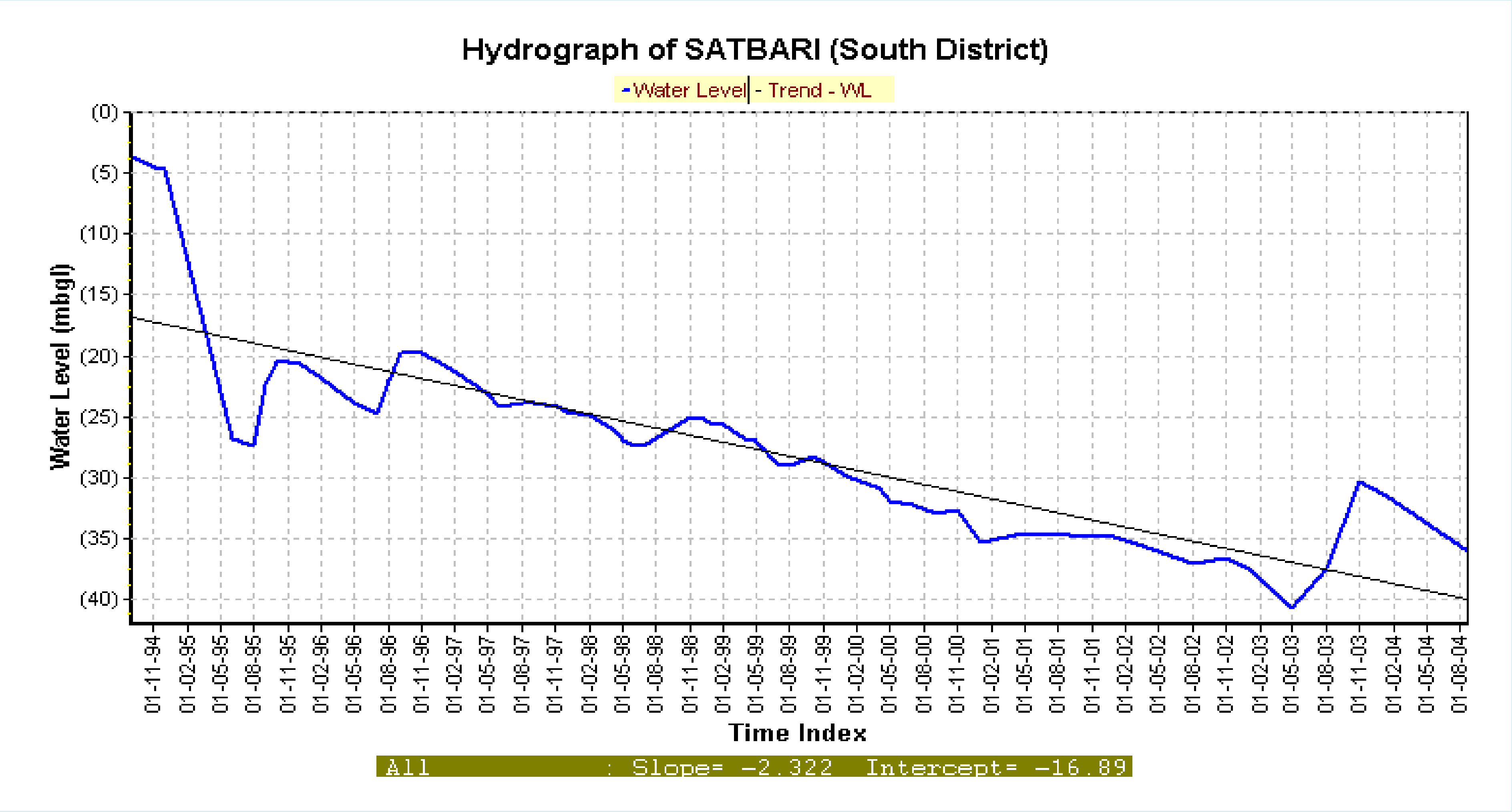
01-11-04
Time Index
All : Slope= -0.899 Intercept= -7.67


Hydrograph of SATBARI (South District)
Water Level - Trend - WL
Water Level (mbgl)
(0)
(5)
(10)
(15)
(20)
(25)
(30)
(35)
(40)
01-11-94
01-02-95
01-05-95
01-08-95
01-11-95
01-02-96
01-05-96
01-08-96
01-11-96
01-02-97
01-05-97
01-08-97
01-11-97
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01-05-98
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01-05-99
01-08-99
01-11-99
01-02-00
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01-02-01
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01-08-01
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01-08-02
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01-05-03
01-08-03
01-11-03
01-02-04
01-05-04
01-08-04
Time Index
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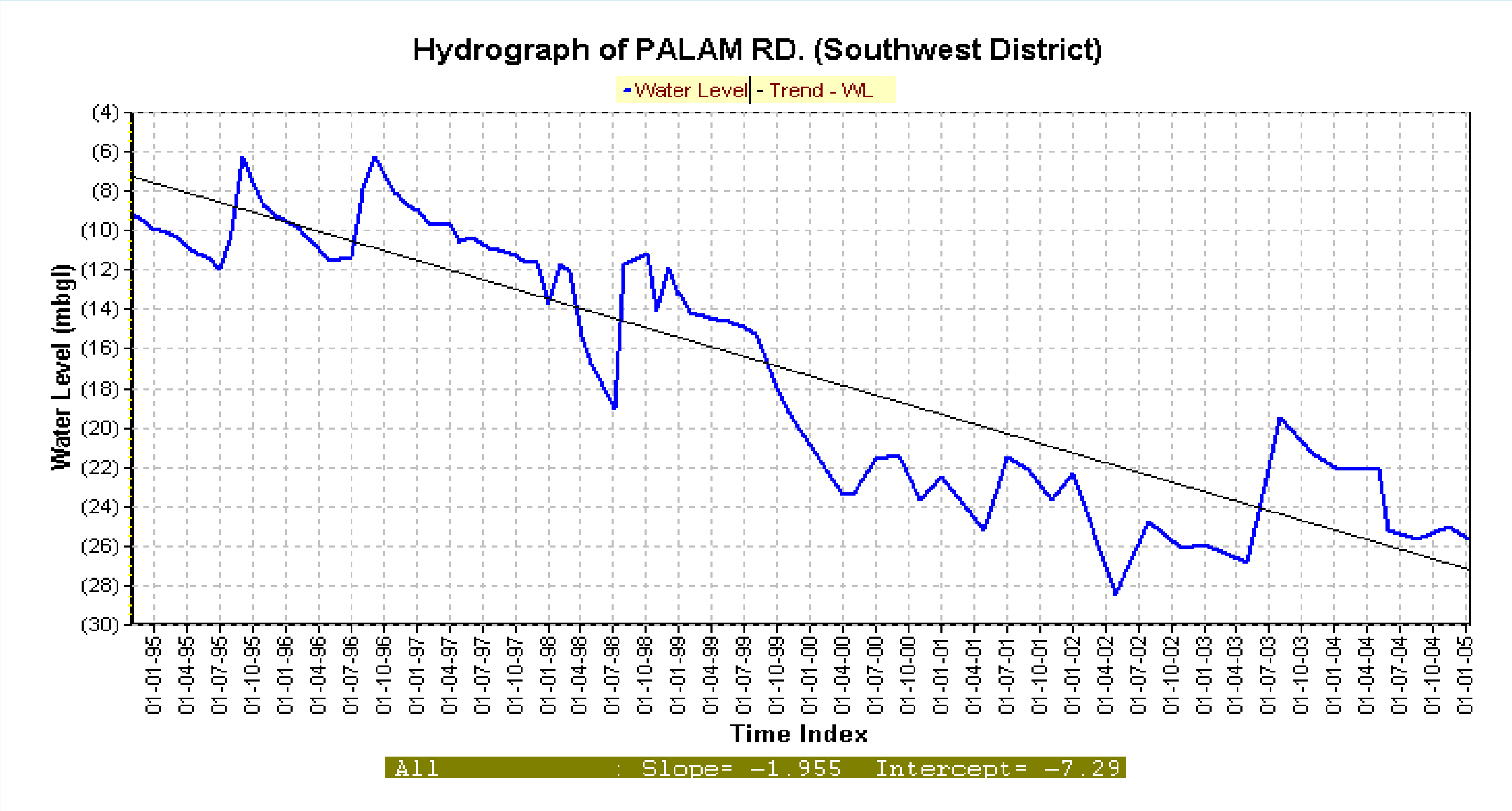

Hydrograph of PALAM RD. (Southwest District)
Water Level - Trend - WL
Water Level (mbgl)
(4)
(6)
(8)
(10)
(12)
(14)
(16)
(18)
(20)
(22)
(24)
(26)
(28)
(30)
01-01-95
01-04-95
01-07-95
01-10-95
01-01-96
01-04-96
01-07-96
01-10-96
01-01-97
01-04-97
01-07-97
01-10-97
01-01-98
01-04-98
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01-01-01
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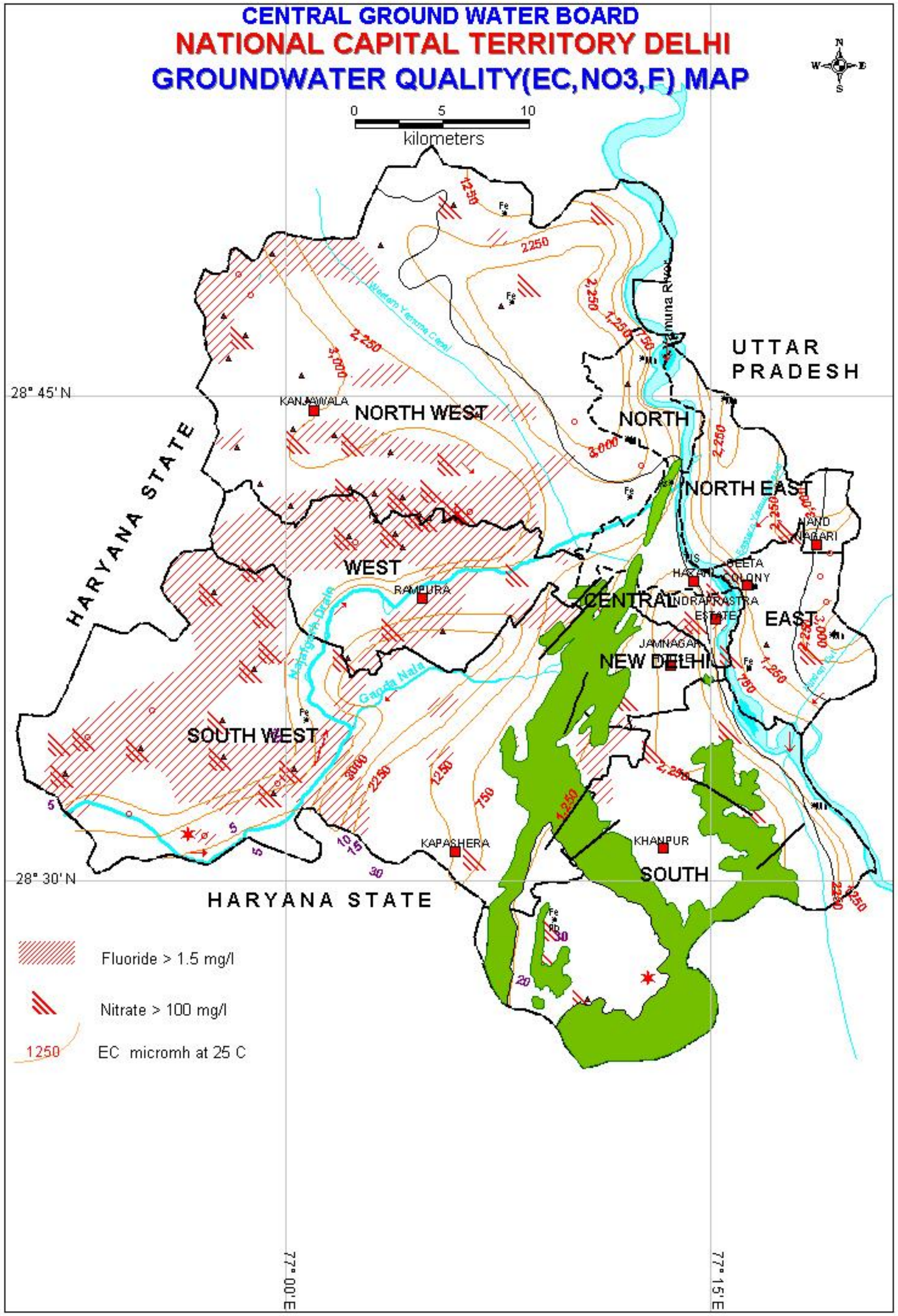
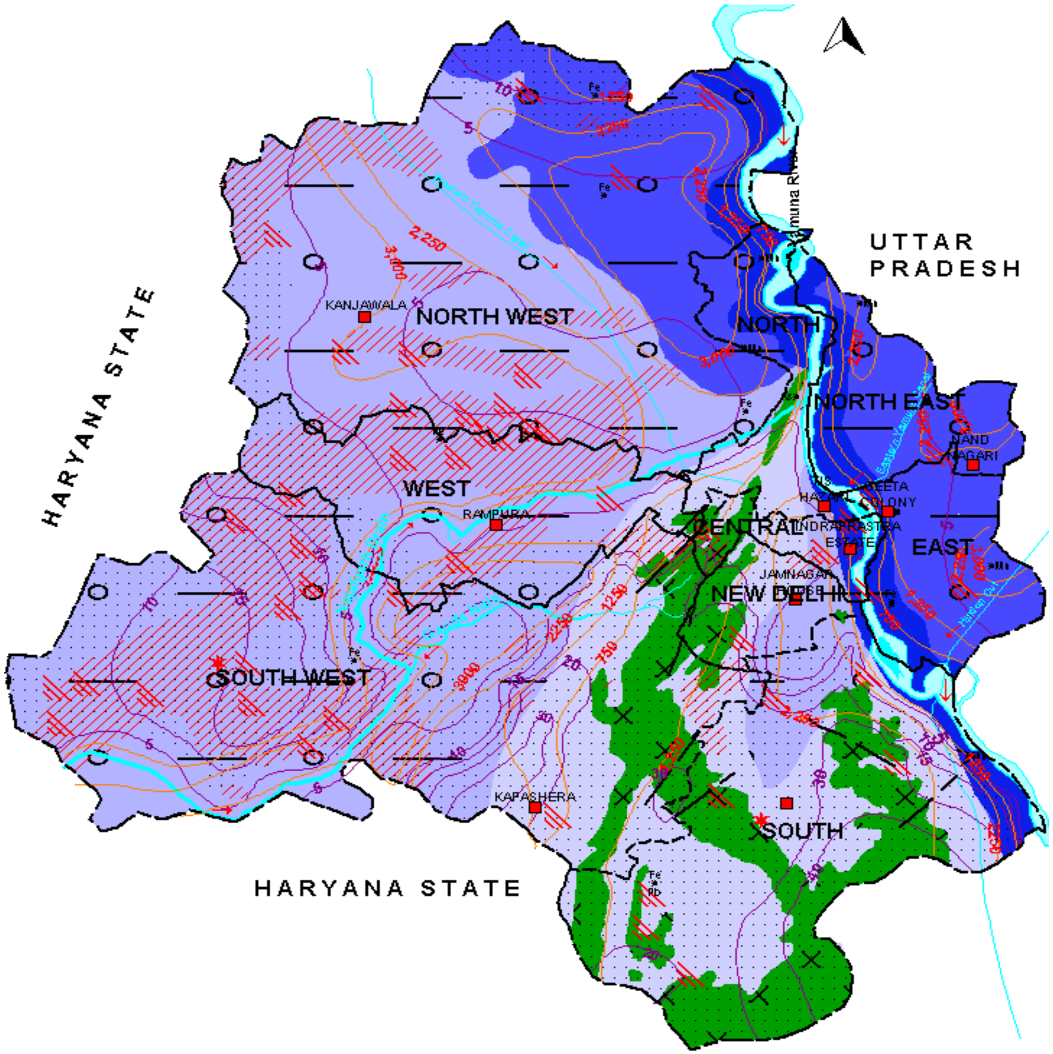
01-04-02
01-07-02
01-10-02
01-01-03
01-04-03
01-07-03
01-10-03
01-01-04
01-04-04
01-07-04
01-10-04
01-01-05
Time Index
All : Slope= -1.955 Intercept= -7.29



CENTRAL GROUND WATER BOARD
NATIONAL CAPITAL TERRITORY DELHI
GROUNDWATER QUALITY(EC,NO3,F) MAP
0 5 10
kilometers
UTTAR PRADESH
HARYANA STATE
HARYANA STATE
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
KANJAWALA
RAMPURA
KAPASHERA
KHANPUR
NAND NAGARI
GEETA COLONY
INDRAPRASTRA ESTATE
JAMNAGAR
Yamuna River
Western Yamuna Canal
Najafgarh Drain
Gaoda Nala
28° 45' N
28° 30' N
77° 00' E
77° 15' E
Fluoride > 1.5 mg/l
Nitrate > 100 mg/l
1250 EC micromh at 25 C

Ground Water User Map of NCT Delhi



LEGEND

Rock Types	Wells feasible & Formation	Rigs suitable	Depth of Well (m)	Discharge (lpm)	Suitable Artificial Recharge Structures **
Soft Rock	Tube Wells Yamuna Flood Plain	Reverse / Direct Rotary	25-65*	300-2400	Not Feasible
Soft Rock	Tube wells Younger Alluvium	Reverse /Direct Rotary	25-45*	300-1500	Shaft/Trench with recharge well, Recharge Pit with/without bore
Soft Rock	Tube Wells Older Alluvium	Reverse / Direct Rotary	25-90*	120-600	Shaft/Trench with recharge well, Recharge Pit with/without bore
Hard Rock	Tube Wells Quartzites	DTH / Rotary cum DTH	60-120*	90-240	Shaft/Trench with recharge well

Depth to Water level in m (Pre-monsoon decadal mean, 1993-2002) 5

Electrical Conductivity (Micro mhos/cm at 25° C) 3000

Major river / Drain

Faults/Lineaments

Fluoride > Permissible limit (1.5 ppm)

Nitrate > Permissible limit (100 ppm)

Iron > Permissible Limit (1.0 ppm) / * Fe

State boundary

District boundary

Tehsil boundary

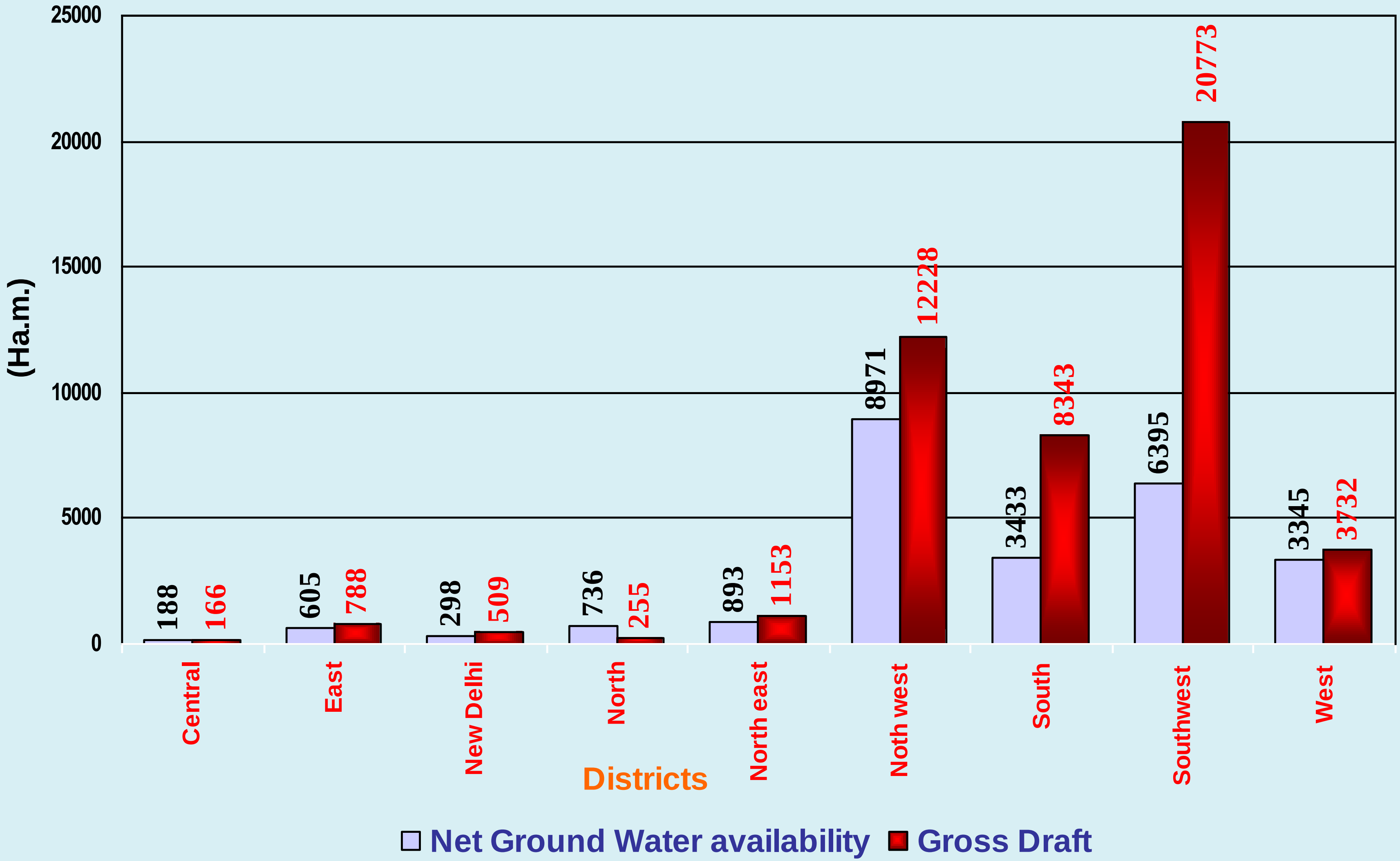
Area feasible for Artificial recharge structures

District head quarter

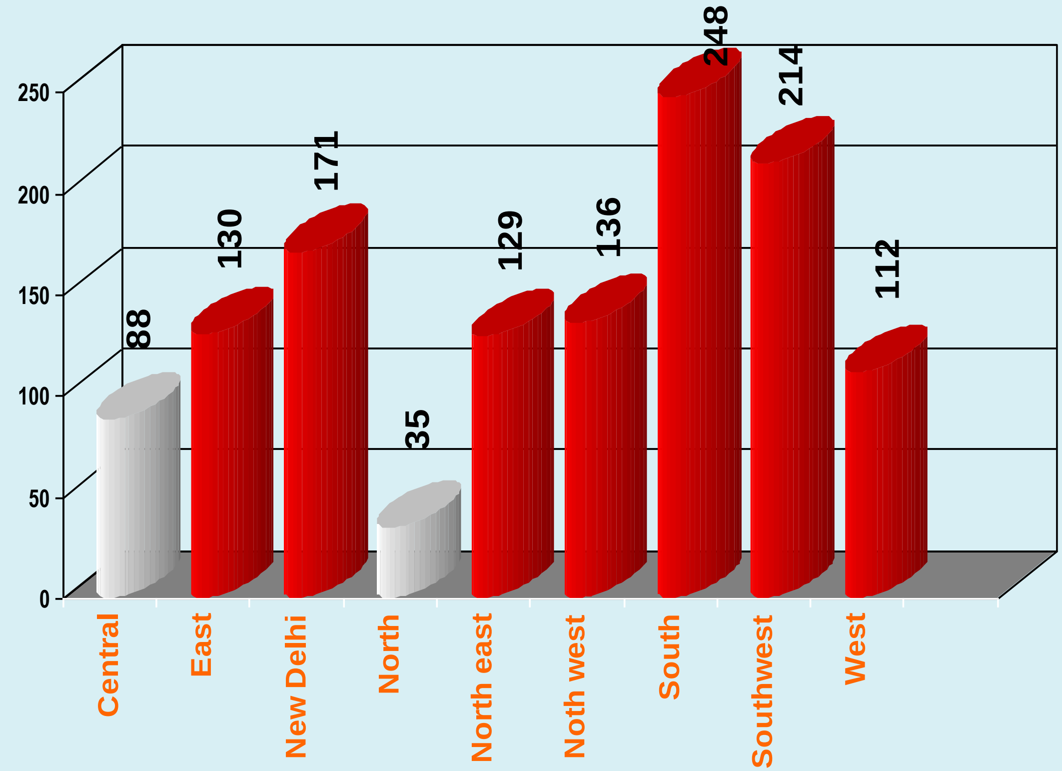
Over exploited block

* Depth of the well is restricted to the availability of fresh water. ** Feasible in areas where depth to wate level is more than 8 m below ground level.

ANNUAL NET GROUND WATER AVAILABILITY AND ANNUAL GROSS GROUND WATER DRAFT (Ha m)



Stage of Ground Water Development



Rain Water Harvesting and artificial recharge to ground water for sustainable development of Ground water resources

- Though Delhi receives normal rainfall of 611.8 mm in 27 rainy days, most of which is going waste as runoff of about 193 MCM.

- It is estimated that the total recharge from Rain water harvesting structures for entire NCT, Delhi is 1390 ha. M (0.139 Cu.m).

- The task force constituted for implementation of rain water harvesting schemes in government buildings, colonies and parks has estimated that about 2.9 mcm rainfall recharge will take place, from the roof top rainwater harvesting structures constructed in Government buildings in NCT, Delhi during normal monsoon in a year. This will facilitate additional rise in ground water level to the tune of 0.5 m in alluvium areas and about 1.0 m in hard rock areas.

Construction of Check dams, Nala bunds and stream diversion channels for creating extra potentiality for ground water recharge

- ✓A total of 17 watersheds have been recognized in the ridge and adjoining areas having estimated runoff of 6.785 MCM in a normal rainfall.

- ✓On-channel storage of storm water in Najafgarh, Mungeshpur, Bawana and Kushak-Barapullah will be the tune of about 122 MCM.

- ✓Four check dams are constructed in JNU-IIT watershed and 2 nala bunds and 2 gabion structures and constructed in Kushk nala. 0.178 mcm of water is being recharge to ground water system in JNU-IIT water shed and 0.142 mcm water is being recharge through nala bunds in Kushak Nala.

FACTORS CONSIDERED FOR PREPARATION OF ARTIFICIAL RECHARGE SCHEMES

HYDROGEOLOGY

- SOIL COVER
- NATURE OF AQUIFER SYSTEM
- DEPTH TO WATER LEVELS
- CHEMICAL QUALITY OF GROUND WATER

AREA CONTRIBUTING RUNOFF

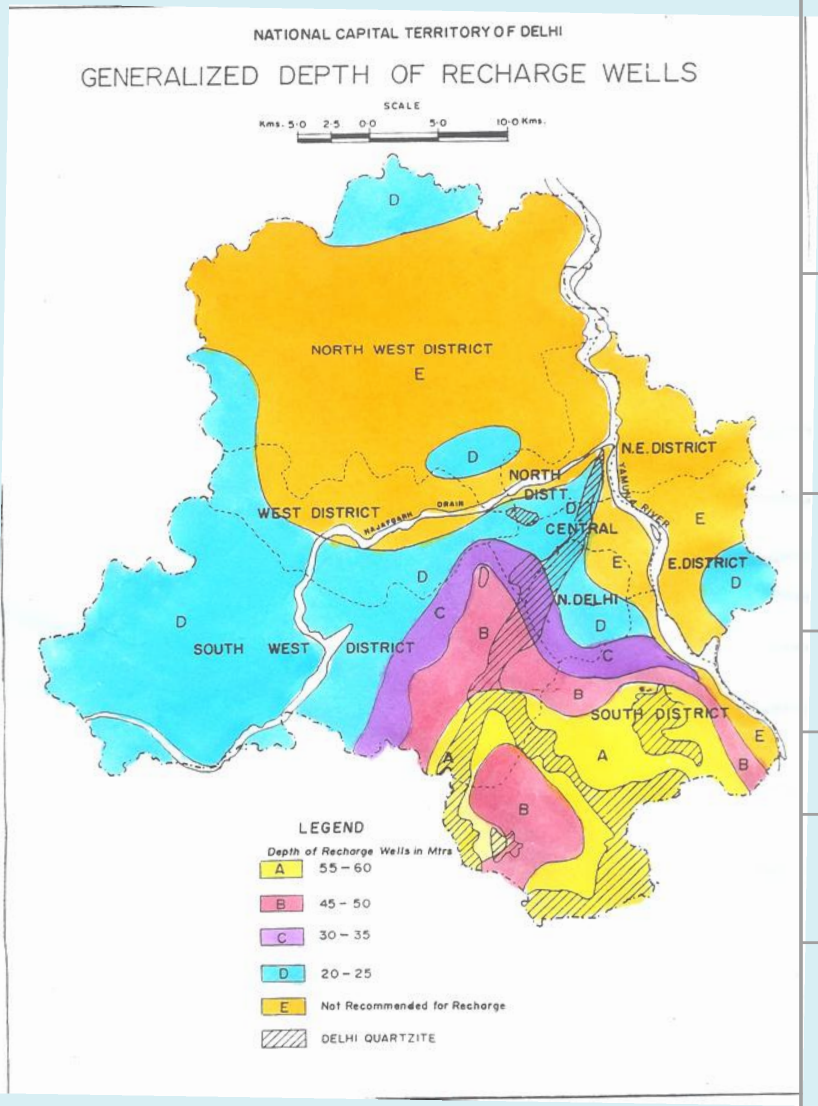
- HOW MUCH IS THE AREA
- LAND USE PATTERN

HYDROMETEOROLOGICAL CHARACTERS

- HOW MUCH IS THE RAINFALL
- PATTERN OF RAINFALL

NCT & NCR Delhi can be divided into Six Artificial Recharge Hydrogeological environments-

1. Newer alluvium with water levels more than 8 m
2. Older alluvium where water levels are 8 to 20 m with unsaturated zone of silty sand mixed with kankar
3. Older alluvium where water level is in between 20 to 40 m bgl
4. Older alluvium with water levels 40 to 60 m bgl
5. Hard rock at shallow depths under the alluvium of 10 to 15 m depth with water levels 30 to 40 m
6. Hard rock from surface itself and depth to water level is 30 to 50 m



District	Zone	Prominent areas of the zone	Generalized depth of recharge wells
South	Zone-A	Tughlakabad, Pushp Vihar, Saket, Ladosarai, Sainik Farms, IGNOU area, Maidangarhi	55 to 60 m
	Zone-B	Chattarpur basin area and farm houses, Greater kailash-I & II, Nehru place, C.R. Park, Okhla Industrial Area	45 to 50 m
	Zone-C	Green park, Hauzkhas, NCERT campus, Lajpat Nagar, South Ext, Ashram Chowk, Friends colony, Defense colony, IIT area	30 to 35 m
Southwest	Zone-B	R.K.Puram, Vasant Vihar, Vasant Kunj, Samalkha, Mahipalpur, IGI Airport, Shankar Vihar, Daulakuan, Naraina	45 to 50 m
	Zone-D	Central and western part of Southwest district- Najafgarh, Jharodakalan, Dwarka, Palam	20 to 25 m
West	Zone-D	Uttamnagar, Janakpuri, Vikaspuri, Rajagarden, Nangloi, Paschim Vihar, Punjabi Bagh, Tilak Nagar, Mayapuri Industrial Area and Rural part of West district	20 to 25 m
Northwest	Zone-D	Parts of Rohini, Pitampura, Narela, Singhola, Wazirpur Industria Area, Udyog Vihar Industrial Area	20 to 25 m
North	Zone-D	Anand parbat, Bara Hindu Rao area, Ghanta garh area	20 to 25 m
Cental	Zone-C	Rajinder Nagar, Karol Bagh,	30 to 35 m
	Zone-D	Parts of Old City area	20 to 25 m
New Delhi	Zone-C	Chanakyapuri, Nehru Park, Sardar Patel Marg, Saroji Nagar, Moti Bagh, AIIMS, Kidwai Nagar	30 to 35 m
	Zone-D	Cannaught Place, Presidents Estate, Parts of Lutyen's Delhi	20 to 25 m
East	Zone-D	Kundli, Vasundhara Enclave, Gazipur Dairy farm, Parts of I.P. Extension	20 to 25 m
Northeast	At present, in this district artificial recharge to ground water is not recommended		

BPCL
Housing Complex,Noida
Total Campus area: 14000 Sq.m

Average Annual rainfall 792.4 mm

Geological Formation-Newer alluvium (Yamuna Sand

0.00 to 18.75	Sand fine to medium grained
18.75 to 21.25	Clay hard and sticky
21.25 to 30.00	Sand fine to medium grained

Depth to Water Levels: 15-18 m bgl

Water available for recharge 4500 Cu.m
Recharge Structures Proposed
Trench with borewells-3 No.
Pit with bore wells – 5 No's

Cost of the Scheme 1.8 Lakhs

Fig. 1

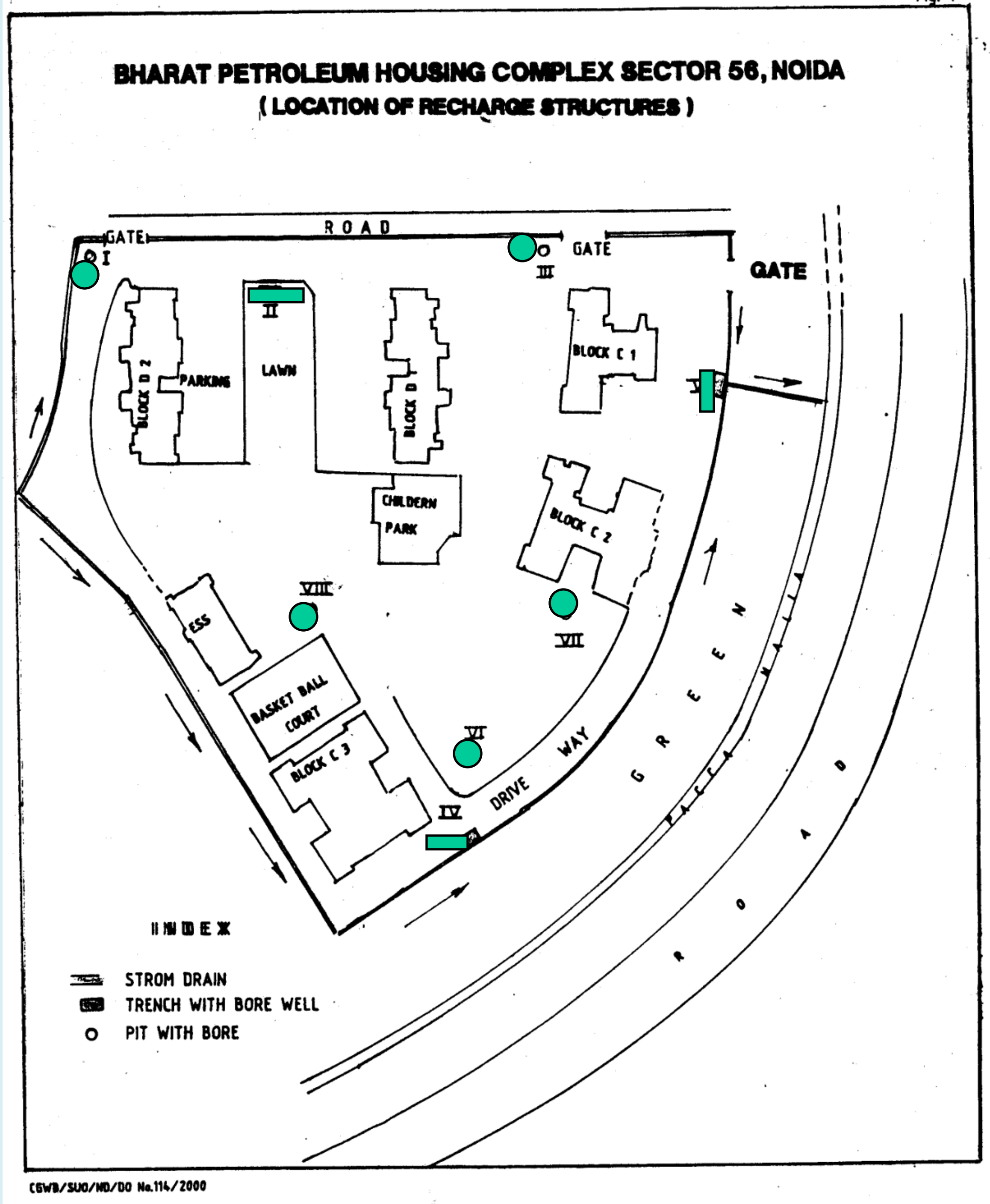
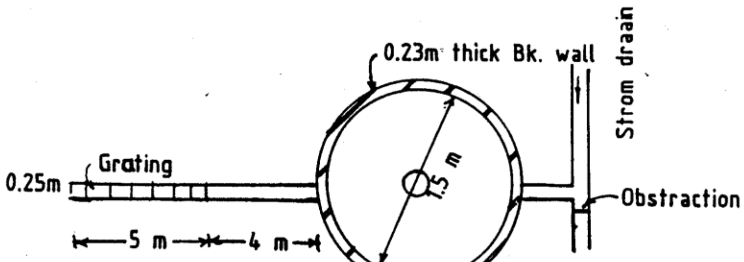
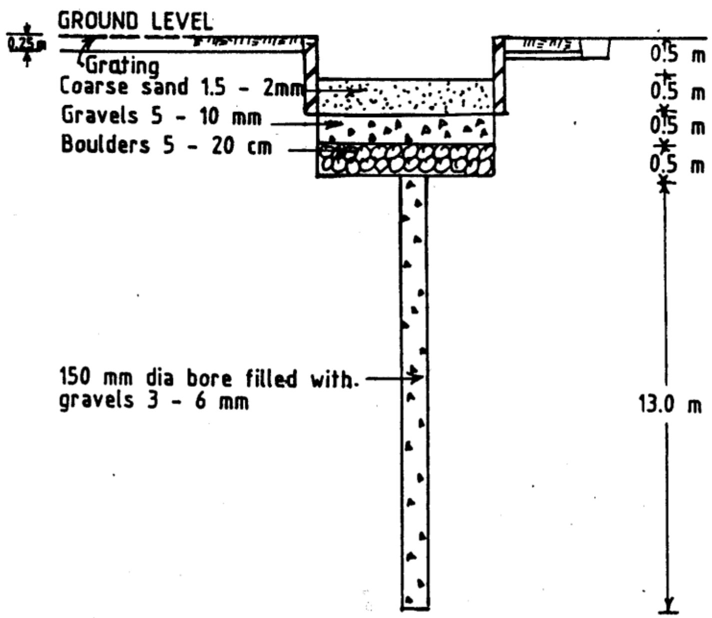


Fig. 2

RECHARGE PIT WITH BORE - 1

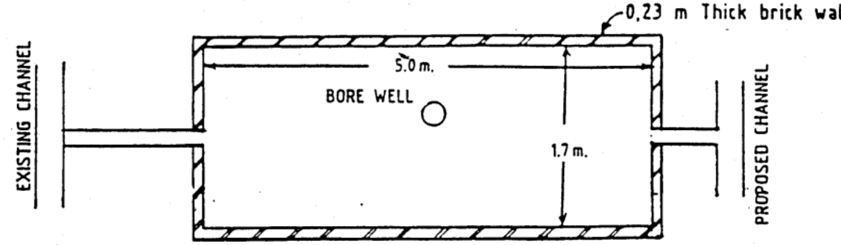


PLAN

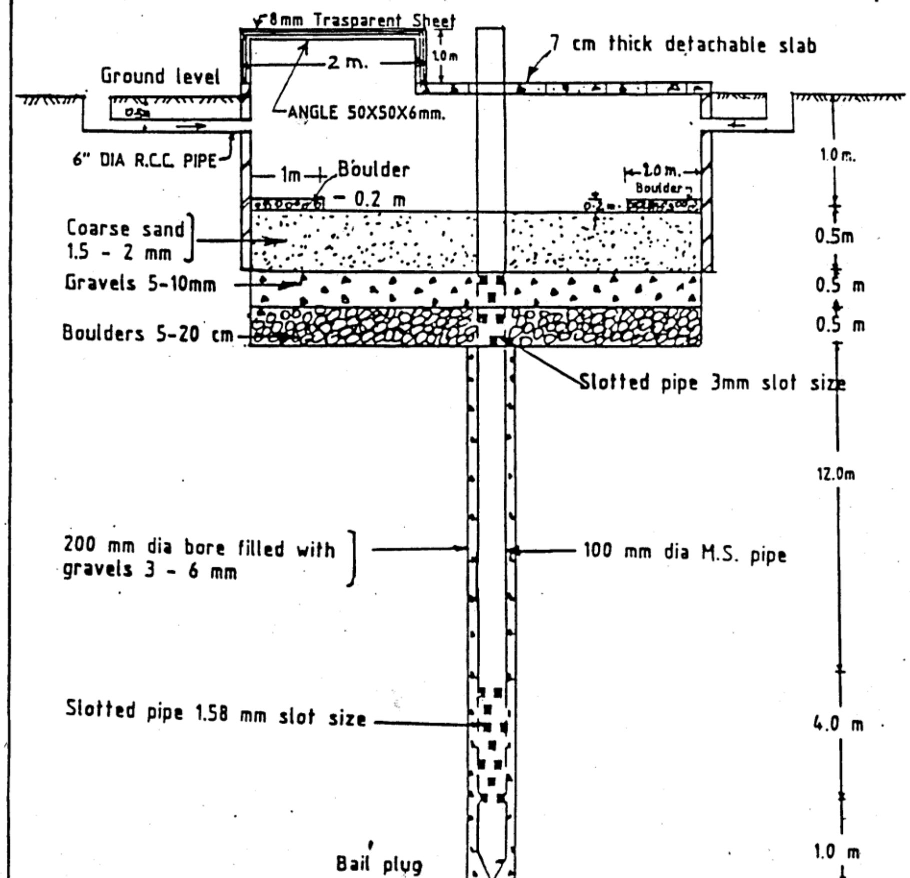


SECTION

TRENCH WITH BORE WELL - 2



PLAN



SECTION

Cost-benefit analysis of BPCL Project

1. Cost of recharging 1000 lts of water: Rs 2.00
2. Expected rise in water levels: 2 m per annum
3. There are two tubewells are present in the campus
4. Saving on energy if water level is raised for 1 m =0.4 KWH
5. 12 hours pumping per day of each tubewell will save 1752 KWH @Rs 2.00 per KWH
6. Saving on Energy by the two tubewells: Rs 7000
7. Thus in 20 years period total saving will be Rs 140000
8. Savings on increasing the pump capacity, delivery pipe etc 50,000
9. Thus recharge to ground water will be a boon to the people dependant on ground water

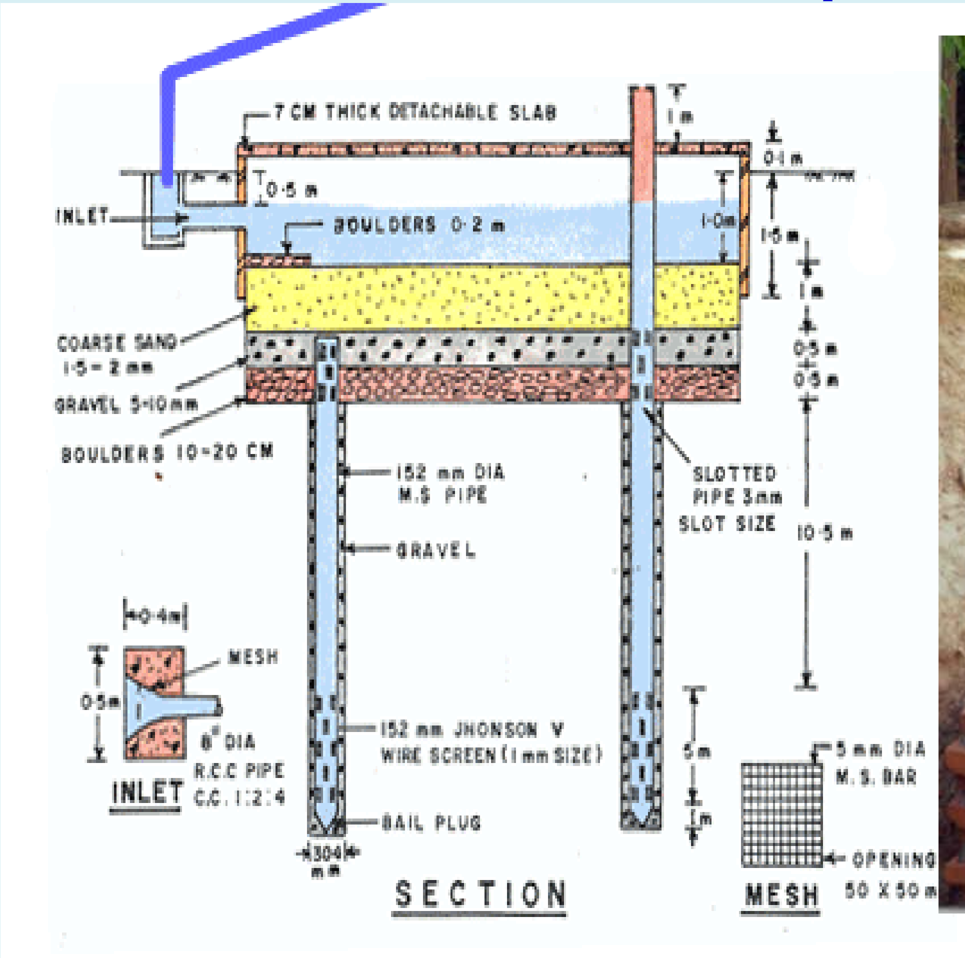
Shram Shakti Bhawan Project

- Total Campus area: 12000 Sq.m
- Roof top area 3110 Sq.m
- Geological formation Clay with kankar at shallow depths followed by silt with kankar
- Depth to water level: 9.5 m
- Expected runoff : 3325 Cu.m
- Recharge structures Recharge trenches with recharge wells-3
- Cost of recharging 1000 lts of water 4.8 rupees
- Rise in water levels in one monsoon period 1.10 m

ENGINEERING DESIGN OF TRENCH WITH RECHARGE WELL

For recharging the shallow as deeper aquifers, lateral trench of 1.5 to 3 m wide & 10 to 30 m long depending upon availability of water with one or more bore wells drives in it may be constructed. The lateral trench is back filled with boulders, gravels & coarse sand.

Approximate cost : Rs. 2000 – 4000 per m. run of trench
Rs. 20000 – 35000 per recharge well



ARTIFICIAL RECHARGE TO GROUND WATER AT PRESIDENT'S ESTATE, NEW DELHI

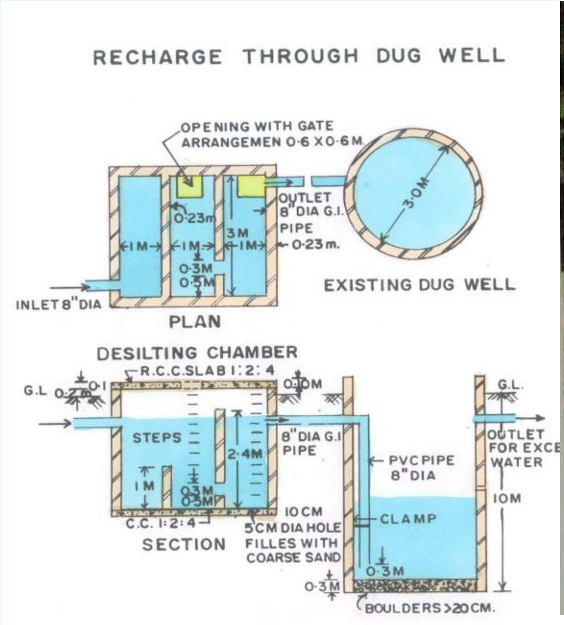
SALIENT FEATURES

- **Campus area:** 1.3 Sq.Km.
- **Source of water:** Rain water & Swimming pool water
- **Av. Annual rainfall:** 712.2 mm
- **Depth to water level:** 6 – 13 m.bgl
- **Water available for recharge:** 31300 cum from the Catchments area of 2,99,000 sq.m

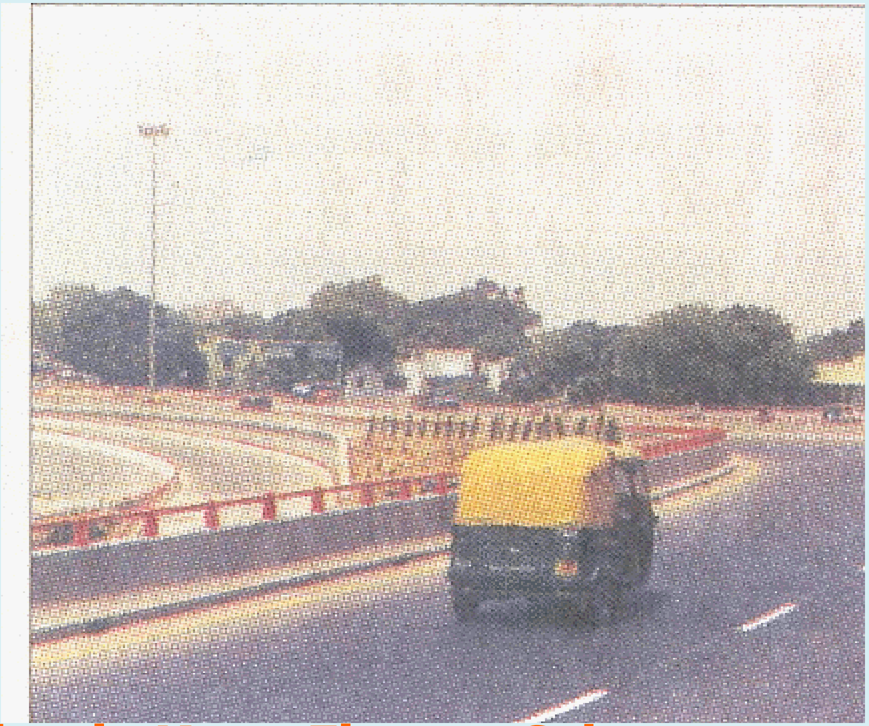
- **Recharge Structures:**

Two existing DugWells
One Recharge well One Recharge shaft
Two Trenches with recharge wells

- **Rise in Water Level during 2003:** Maximum Rise upto 4 m

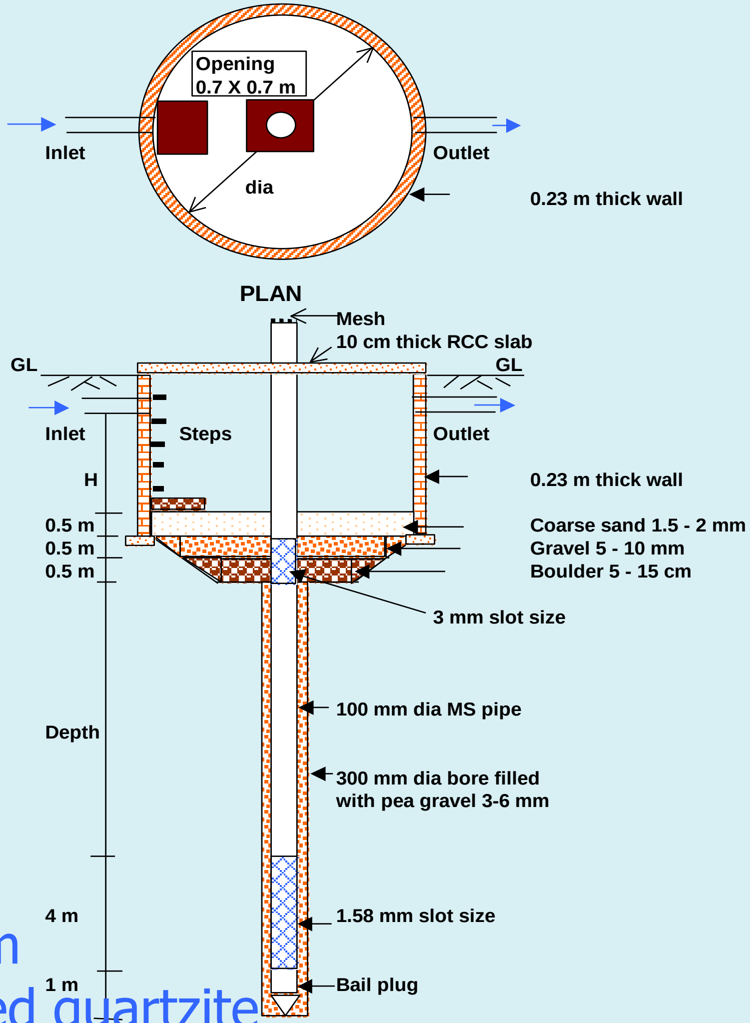


RAINWATER HARVESTING OF RUNOFF FROM FLYOVERS



Dhaula Kuan Flyover Scheme

SHAFT WITH RECHARGE WELL



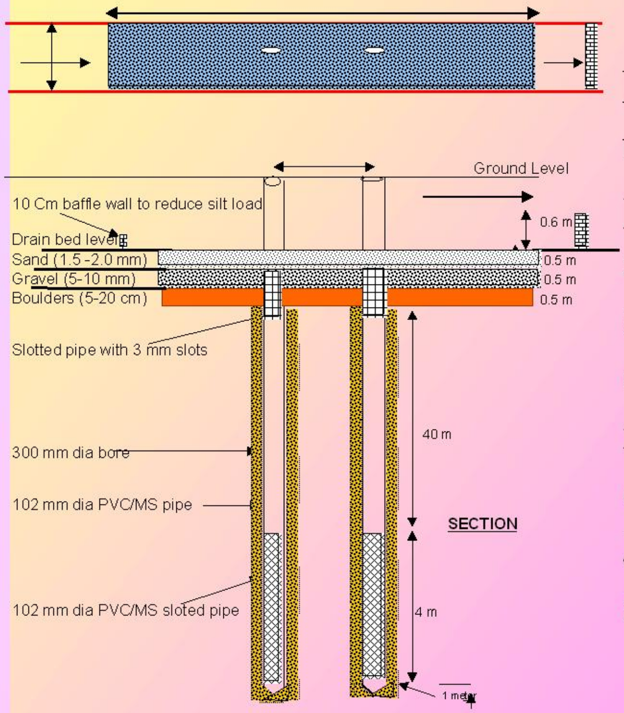
- **Catchments area** : 13.75 Hectares
- **Average Annual Rainfall** : 712.2 mm
- **Geological Formation** : Weathered quartzite
- **Water Availability** : 39244 cum.
- **Recharge structures** : Shaft with Recharge well – 16

Pond with Recharge well –1

Pit with Recharge well –3

Drain bed as Recharge Structure

Recharge Structure on the Drain Bed



Drain beds can also used for recharging purpose-These type structures can be constructed in the drain bed which is newly being constructed in Jaunapur farm hous areas

Artificial Recharge Scheme in Vayusenabad, Air Force Station, Tughlkabad, New Delhi

✓Total catchment area is 190000 Sq.mts.

✓Annual runoff is about 18190 Cu.mts

✓Complete runoff generated in the colony is being recharged through four recharge trenches with tubewells.

✓During the monsoon season of 2002, the scheme was monitored and it is found that about 4 m rise in water levels in the colony.

✓The discharge of tubewells present near the structures has increased to about 250 LPM from 100 LPM and sustained for 20 to 25 days

Recharge through abandoned handpumps or 4” dia shallow tubewells

Recharge through tubewell

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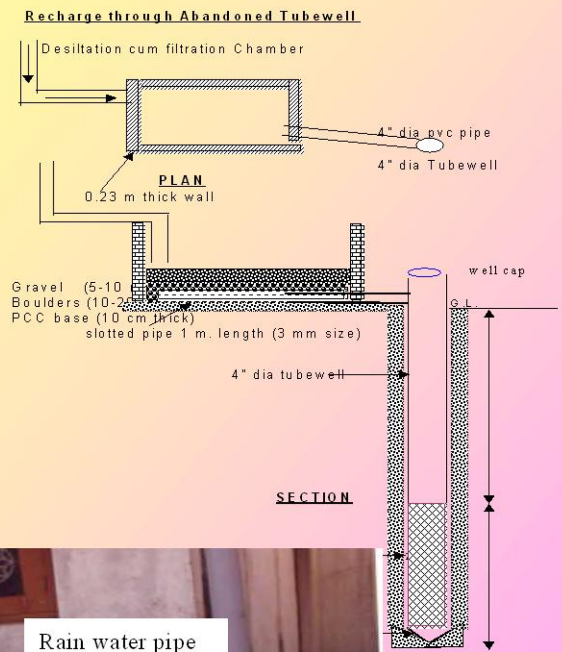

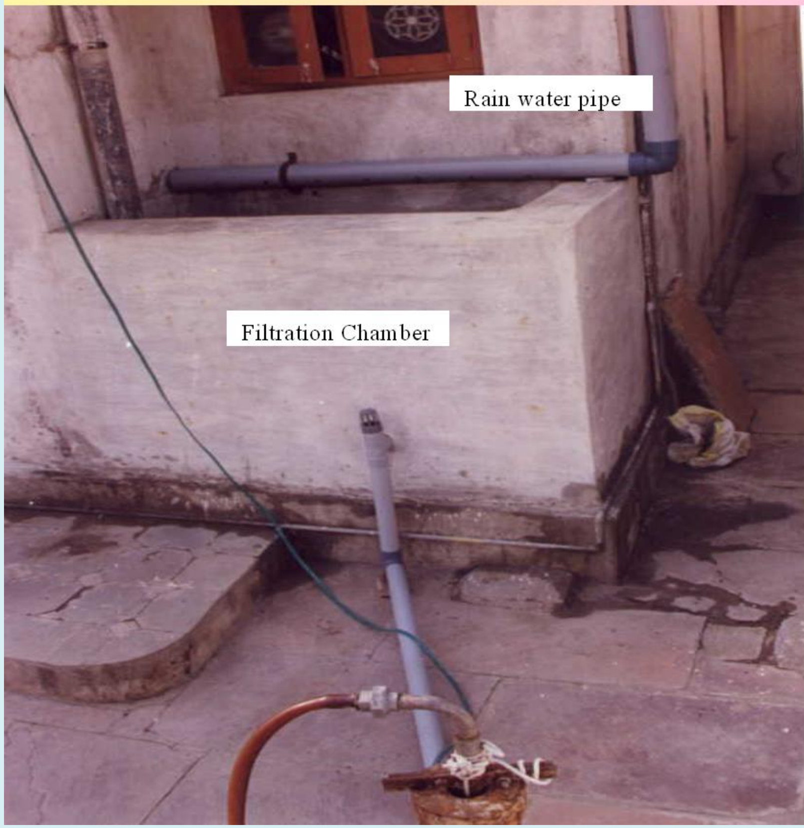

❖Because of alarming rate of decline in water levels, the tubewells and hand pumps are being disused and new tubewells are being constructed.

❖The abandoned hand pumps and tubewells can be used for recharging purpose by diverting the rooftop water through a small filtration chamber.

❖The cost of converting the handpump and abandoned tubewells is very minimum and at individual level can be takenup.

❖CGWB has encouraged to construct cost efficient structures to a number of individuals eager to takeup RWH to arrest the declining ground water levels.

PERCOLATION PONDS WITH RECHARGE STRUCTURES (TRENCHES WITH TUBEWELLS)

The efficacy and feasibility of these structures is more in hard rock formation where the rocks are highly fractured and weathered. The percolation tanks with wells and shafts inside it are constructed to recharge aquifers.

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