Centre for Science and Environment

CAPTURING RAINWATER

A way to augment Chandigarh's water resources

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Prepared by
Water Management Team
Centre of Excellence, Sustainable Water Management

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Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi-110062
Phones: 91-11-29955124, 2995125
Fax: 91-11-29955879
Email: cse@cseindia.org
Web: www.cseindia.org

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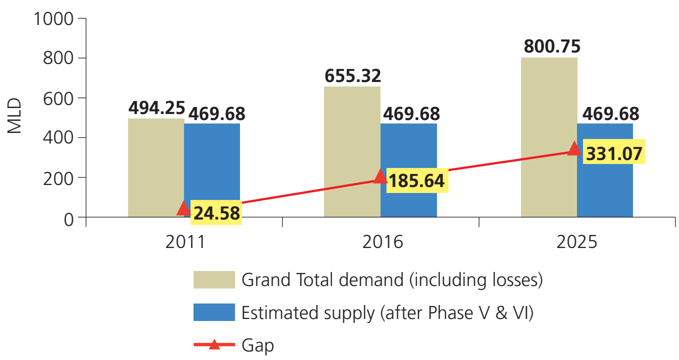
Executive summary

1. WHY SHOULD CHANDIGARH HARVEST RAINWATER?

Chandigarh is a rapidly growing city and in the last decade (1991-2001), its population growth rate was 40%. Its population density of 7900/sq km is one of the highest in the country and its demand for water is estimated to grow steeply. It is estimated that by 2025, the water demand will be 800 MLD, an increase of 58% over the 2011 demand of 494.25 MLD.

All urban centres are water guzzlers, and Chandigarh will need even more water as the city has large water needs for horticultural purposes. Almost one-third of the total area is under green spaces.

GRAPH: DEMAND-SUPPLY SCENARIO



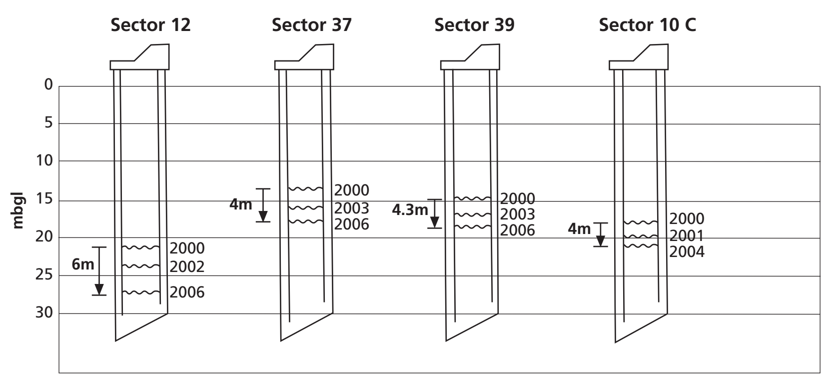
Year	Projected population (lakh)
2011	14.38
2016	17.8
2025	24.88

Source: Statistical Abstract, Chandigarh Administration website

It has no surface water source. It has been getting water from the Bhakra Main Canal and already there is a dispute concerning water for the next two phases of supply. Therefore, options for augmenting surface water supply are limited.

Chandigarh taps the deep, confined aquifers for water supply. A confined aquifer can only be recharged naturally in places where it is exposed to the surface. In Chandigarh, natural recharge of confined aquifers is not taking place and yet, water is being pumped out from these aquifers. The deep, confined aquifers of Chandigarh are therefore, in decline.

FIGURE: GROUNDWATER DECLINE IN DEEP AQUIFERS



Source: National Data Centre, CGWB, Faridabad

To ensure long-term sustainability of water sources for the city, rainwater harvesting is a simple and effective solution. It can be done using roads, roundabouts, parks, rooftops, paved areas – almost the entire city.

2. HOW MUCH WATER CAN CHANDIGARH GET FROM RAINWATER HARVESTING?

The rainwater harvesting potential of Chandigarh, with an area of 114 sq km, assuming a co-efficient of 50%, and the average annual rainfall of 1059.3 mm is 60380.1 million litres or 13241.25 million gallons or 36.28 MGD. This is more than the water pumped out of aquifers and therefore, harvesting and recharging rainwater will go a long way in contributing towards sustainability of water supply.

3. HOW AND WHERE CAN WE UNDERTAKE RAINWATER HARVESTING IN THE CITY?

1. By recharging the deep, confined aquifers
2. By storing water in tanks or ponds and water bodies.

Recharging deep, confined aquifers: If you look at the tubewell map of the city, you can see that tubewells have been drilled all across the city and also just outside the city limits in the vicinity of the Sukhna Choe and the Patiali ki Rao choe. Recharge structures can therefore be built across the city and near the choes.

- The simplest way to do recharge would be to tap the storm water drain network. Structures can be built next to the storm water drain by tapping the water from it and using the rainwater to recharge the aquifer after proper filtration.

- There is a concentration of tubewells in the areas around and near the Sukhna choe in the south and the Patiali ki Rao choe in the north. As these areas have good sandy layers with appreciable thickness, these areas have high potential for rainwater harvesting.

Storage: In addition to recharge, storage structures can be built for rainwater harvesting. These can be either in the form of tanks in commercial and institutional areas or ponds in green areas. For instance, the Municipal Corporation has built such ponds in the Botanical Garden.

4. WHAT ARE THE BENEFITS OF USING THE STORM WATER DRAIN NETWORK FOR RECHARGING?

- The Administration is tapping water from confined aquifers almost in all sectors; Chandigarh's storm water drain network covers the entire city. A simple way to recharge the aquifers is to construct recharge structures along the storm water drain network and tap the rainwater flowing through it (see Map: *Location of deep tube wells and storm water drain network*).

- The drain network is a covered facility and thus the chances of polluted water entering the drain network are limited.

- Currently all the rainwater goes out of the city as the storm water drain tail ends are in the Sukhna choe or in the N-choe which take the water away from the city. By making recharge structures along the storm water drains the water can be used to recharge Chandigarh's aquifers.

- The storm water network collects water from the roads (15.89 sq. km), from rooftops of residential areas, (30.19 sq.km) from shopping areas (3.97 sq. km), public and institutional buildings (7.94 sq. km). This amounts to more than 70% of the total land area. The total quantum of water that would be available for recharge annually would be
  58 sq km (area) x 1059.3 (rainfall) x 0.5 (rainfall coefficient) = 30720 million litres.

Even if we assume the rainfall to be 1000 mm and use 40% collection efficiency, the total water that can be recharged annually would be 23200 million litres or 13.94 million gallons daily. This is equivalent to 70% of the total groundwater supply and is available only from tapping the storm water drain network. .

5. HOW MANY RECHARGE STRUCTURES CAN BE MADE ON THE ROADS AND WHAT WILL IT COST?

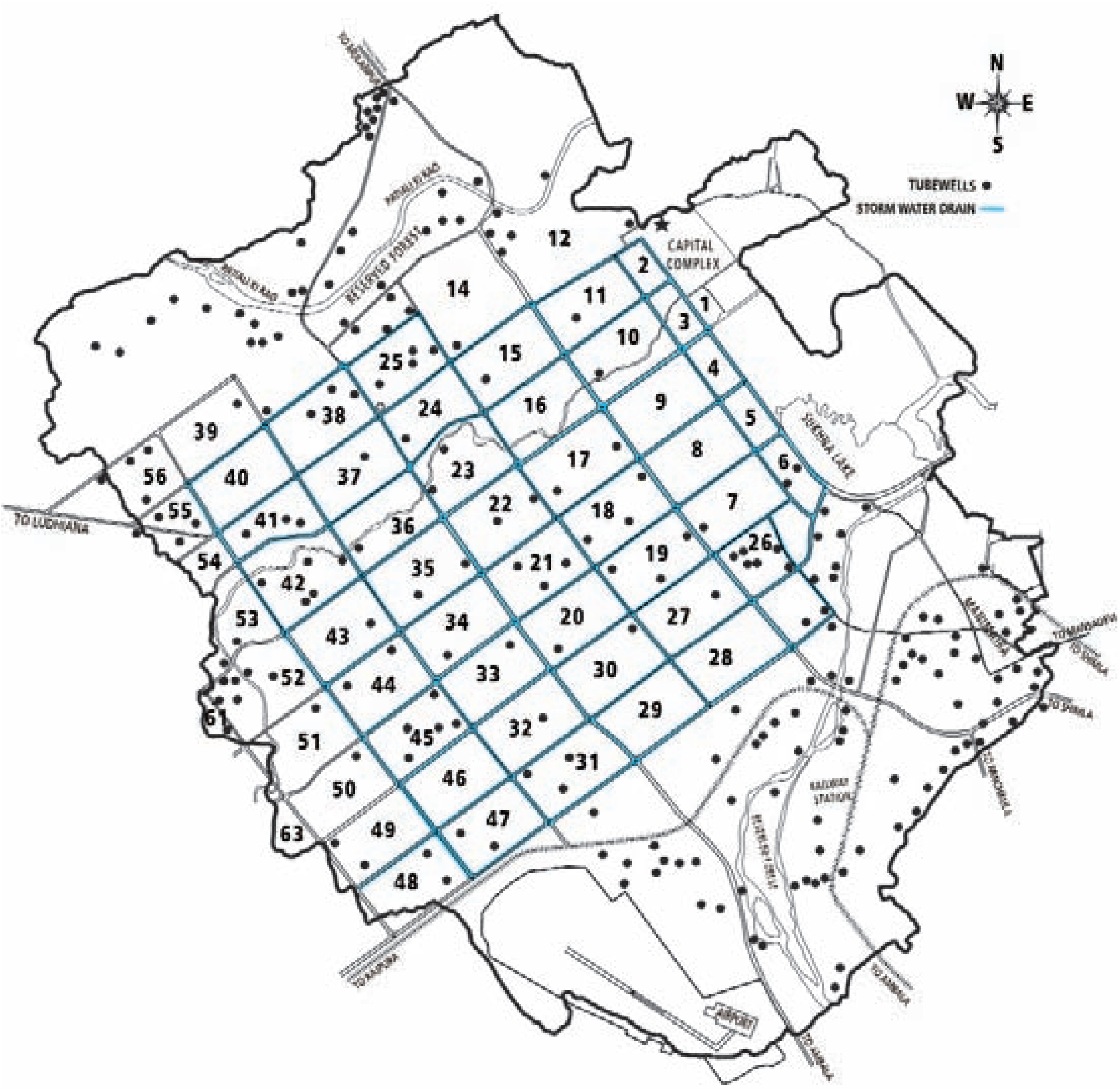
The planning has been done for a typical sector measuring 1200m by 800m. In some of the sectors there are storm water drains on all four sides and in some, only on three sides. Assuming that recharge structures are made at an interval of 50 m, there can be a minimum of 55 recharge wells and 50 recharge trenches and a maximum of 70 recharge wells and 64 recharge trenches for a sector.

The cost of a typical recharge well with desilting chamber is Rs. 40,500 and a recharge trench is Rs. 53,135 (see Table: *Costs for recharge structures for a typical sector*).

If we take an average of Rs. 25 lakh for a sector, the total cost for 56 sectors would be Rs. 1400 lakh (14 crore).

The annual maintenance cost arises only from cleaning of the desilting chamber, cleaning of filter materials and declogging the bore.

MAP: LOCATION OF DEEP TUBE WELLS AND STORM WATER DRAIN NETWORK



Source: PH Department, MCC

TABLE: COSTS FOR RECHARGE STRUCTURES FOR A TYPICAL SECTOR	No of recharge wells	Cost of recharge wells (Rs)	No of recharge trenches	Cost of recharge trenches (Rs)
Typical sector with drainpipes on 3 sides	55	55 x 40500 = 22,27,500	50	50 x 53135 = 25,56,750
Typical sector with drainpipes on 4 sides	70	70 x 40500 = 28,35,000	64	64 x 53135 = 34,00640

6. WATER FOR ALL: TODAY AND TOMORROW

Against the background of the envisaged economic growth and the resulting population growth, the water needs of Chandigarh will grow at an explosive rate. But water availability will not grow in parallel leading to water stress and resultant conflicts. There is a need to put in place a number of measures to create awareness among the people about the importance of water and incentivise them to use water carefully and wisely. These will include policy measures (legal, financial), research, capacity building and education measures. Water conservation measures include: (a) Rainwater harvesting; (b) Recycle and reuse of water; and, (c) Reducing water use.

The first step is to create a central authority to coordinate all water conservation and augmentation measures (Rainwater Harvesting or Water Conservation Cell). The next step is define clear and definite short-term and long-term measures and targets, identify funding sources and secure adequate funding. Bulk users and institutional buildings must be targeted first.

Short-term measures: This will include legal, administrative and financial measures on the one hand, and awareness creation and capacity building on the other. They go hand in hand and must be initiated together. To catalyse citizens and public institutions to become water-wise, legal and administrative measures can be put in place. These include amendment of bylaws to make water conservation measures mandatory, financial and administrative incentives such as rebates on water bills, property taxes, award programmes etc. Pricing of water is a key instrument to ensure that consumers use water carefully.

Long-term measures: A focussed programme to encourage research on such issues as hydrogeological and rainfall mapping, filters, technological tools must be instituted. Detailed maps of each zone can be created for recharge zones, flood-prone areas, water quality and water bodies that can be revived etc. Detailed studies can be initiated using GIS, satellite imageries.

Before exhorting the public to use water wisely, the Administration must lead by example by instituting measures for wise use of water in its own buildings. Rainwater harvesting must be implemented in all government buildings and public spaces such as parks, stadia etc. As Chandigarh's soil is suitable for constructing water bodies, the MCC must plan for water bodies in green areas and particularly in the southwestern sectors, where there is water logging. Public and commercial buildings must be made to implement water conservation measures in a targeted manner.

Rainwater harvesting: The first step to encourage rainwater harvesting in the city is to create a Rain Centre that will serve as a central repository of information on all aspects related to rainwater harvesting. The Rain Centre will have posters, models, and training facilities. It will be staffed with technical experts to provide technical help to common people. The Rain Centre will also serve as a centre for providing training and capacity building to a cross-section of people from masons and plumbers to consultants and architects.

A key system that must be set up will be an Inspection and Maintenance programme to ensure that all rainwater harvesting systems are kept in good order. A systematic programme to regularly clean and maintain the systems must be put in place.

Recycle and reuse of sewage: Although Chandigarh is the first city to have a system in place for treating and reusing sewage, this centralised system can be supplemented by decentralised sewage recycling systems. As the N-choe is greatly polluted with untreated sewage, decentralised sewage treatment systems can be easily set up in that area and the sewage can be gainfully used in horticulture. This will serve to reduce the cost of supplying centrally treated water.

Water efficient fixtures: There is an increasing trend the world over to reduce the use of water by designing water efficient fixtures. In countries like Australia, Canada and the US, laws have been brought in to make it mandatory to replace old fixtures that use more water with water-efficient fixtures. Therefore, the Chandigarh administration should also look at policy initiatives to facilitate the change over to the use of water- efficient fixtures. These can include labelling of water-efficient fixtures, rebates on the fixtures, rebates on water bills. In addition, the Administration can go in for a focussed replacement programme of all older, water guzzling fixtures.

The most common water efficient fixture is the flush toilet and in India, low-flush or dual flush toilets are already being used widely. Water taps, washing machines are other fixtures where efficiency can be brought in. Currently the Ministry of Urban development is undertaking a study to initiate a programme of labelling of water efficient fixtures similar to the star rating system for electrical appliances. This will greatly help in motivating consumers to switch over to the use of water efficient fixtures.

1. Chandigarh: the city

1.1 BACKGROUND AND HISTORY

Chandigarh is famously known as the first planned city of independent India, and was planned as a symbol of the aspirations of the new republic. It was primarily created to meet the need for a new capital for the state of Punjab after independence. The task of planning the city was first assigned to the American planner, Albert Mayer and his partner, Matthew Nowicki. Mayer pulled out of the project after the death of his associate and Le Corbusier was brought into the project in 1951.

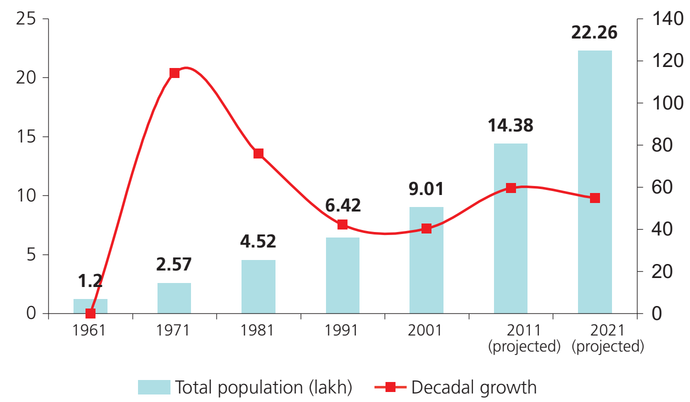
A gently sloping plain measuring 114 sq km, at the base of the Siwalik Range of the Himalaya and located at 30.74º North and 76.79º East, was chosen as the site for the new capital city. It was named Chandigarh after a temple dedicated to the goddess, Chandi, and a fort (garh) which were situated in one of the villages acquired for the city. The site was bounded by two seasonal rivulets, Patiali-ki-Rao and Sukhna Choe, marking its northwest and southeast boundaries. The elevation of 333m above sea level moderates its severe summers.

Le Corbusier's most significant contribution was the conception of the city as a human form – the Capitol complex forming the "head"; the City Centre forming the "heart"; the industrial and the University areas serving as the "limbs". The basic unit of urban planning was the "Sector" and the entire city was designed within an ordered framework of "sectors" that look like a chess board. Corbusier also implemented his idea of urban circulation through the hierarchy of roads, called the seven Vs that gives Chandigarh its distinctive character. Beginning with the V1 roads that connect the city with the outside world, the V2 roads are the major roads that cut acrooss the city (the Jan Marg, Dakshin Marg, Madhya Marg). V3 roads surround each sector and are meant for fast traffic, while V4 roads connect adjoining sectors and are the main shopping streets. The vertical green belts, with the pedestrian V7, contained sites for schools and sports activities. A typical sector measures 1200 m x 800 m in area, and shopping and green areas cut across all sectors.

Chandigarh was the capital of Punjab until 1966, when the state was bifurcated into Punjab and Haryana, and it was then made the joint capital of both states. At the same time, it was also designated as a Union Territory to be directly administered by the central government. Of the total area of 114 sq km, 79.34 sq km is designated as urban area and the remaining 34.66 sq km as rural area comprising 18 villages. The MCC came into being in 1994 through an extension of the Punjab Municipal Corporation Act, 1976.

The city was originally planned for 1.5 lakh people and the first 30 sectors were planned for this population. Later 17 additional sectors (Sectors 31-47) were planned as the population increased to 5 lakh. As per the 2001 census, Chandigarh

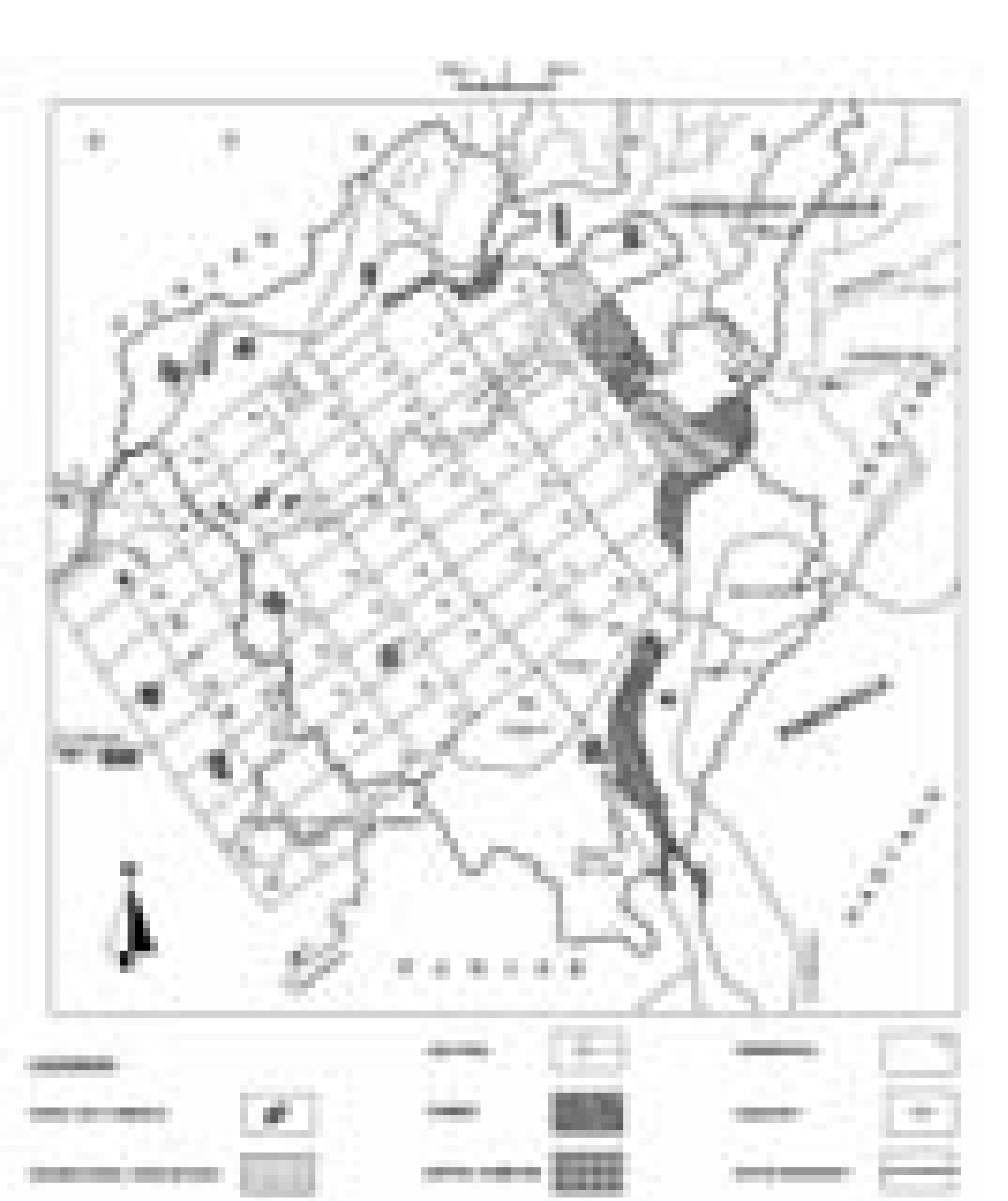
GRAPH: **POPULATION GROWTH**



Source: Statistical Abstract, Chandigarh Administration website

TABLE: **DECADAL GROWTH OF POPULATION**

Decade	% of decennial growth
1961	---
1971	114.17
1981	75.88
1991	42.04
2001	40.34
2011 (projected)	59.60
2021 (projected)	54.80



Source: Y. Singh, Siltation problems in Sukhna Lake in Chandigarh, NW India and comments on geohydrological changes in the Yamuna-Satlej region.

had a population of 9,00,635, 89.8% of which was urban population and the slum population was 1 lakh (12%). The decadal growth in population between 1991 and 2001 was 40%. In 2009, the city had a population of 12.97 lakh[1]. The city is also one of the most densely populated cities in the country with a population density of 7900 per sq km.

Today, Chandigarh is emerging as a regional hub in areas such as education, health, information technology, food processing and service industries. Several new initiatives are being planned such as the Medi City, IT Park etc for the coming years. The Administrations' e-sampark project has won the Golden Icon award. Chandigarh was adjudged the best city in terms of quality sanitation under the National Rating and Award Scheme for Sanitation in May 2010 by the Ministry of Urban Development.

2. Chandigarh: Water profile

2.1 WATER SUPPLY

The responsibility of water supply and sewerage rests with the Public Health Department of the municipal corporation. The Superintending Engineer (Public Health) has the overall responsibility for water supply, sewerage and storm water drainage. Under him there are four divisions, each under an Executive Engineer. Each of these divisions has several sub-divisions that cover the entire municipal area of the city.

The city was being supplied with water from groundwater wells till 1983. The exploding population of the city forced the administration to look for a surface water source to supplement the ground water supply. Today, Chandigarh city gets 67 MGD of water from the Bhakra Main Canal and 20 MGD of groundwater from 200 tubewells in the city, making the total available water at 87 MGD or 396.72 MLD.

2.1.1 Canal water supply

In 1983, the administration commissioned the first phase of Kajauli Water Works from the Bhakra Main Line at a distance of 27.5 km from Chandigarh to provide 20 MGD of water to Chandigarh city and its satellite towns of Mohali and Panchkula. Another 20 MGD was commissioned under Phase –II in 1988, and the third and the fourth phases were commissioned in 1994 and 2006 to bring in additional water supply of 40 MGD.

The agreed share of water from the Kajauli Water Works is as follows:

TABLE: **CANAL WATER SUPPLY**

Cities	Phase I MGD	Phase II MGD	Phase III MGD	Phase IV MGD	Total MGD	Remarks
Chandigarh	14.5	14.5	14.5	14.5	58	For Chandigarh
Mohali	2.5	2.5	2.5	2.5	10	For Punjab
Panchkula	1.5	1.5	1.5	1.5	6	For Chandigarh
Chandi mandir	1.5	1.5	1.5	1.5	6	For Chandi Mandir
Extra from Punjab					3	
Total for Chandigarh					67	

Source: Executive Engineer, PH-I, Municipal Corporation Chandigarh (MCC)

However, Panchkula has not been availing itself of its share of water and this is used by Chandigarh. Chandigarh also gets an additional 3 MGD of water from Punjab. Thus, as of today, Chandigarh gets 67 MGD from Kajauli. This water is pumped to Chandigarh, Sector 39, which is at a higher elevation of 177 feet. There is a loss of 1% water due to leakage.

At Sector 39, there is a filtration plant of 70 MGD capacity and a storage capacity of 42 MGD for raw water. Treated water is sent to underground reservoirs at Sectors 26, 32, 37, 12, 52 and 39 with a total capacity of 50 MGD.

Projected augmentation of canal supply: The Chandigarh Administration has planned for further augmentation of the surface water supply scheme at Kajauli Water Works to provide an additional 32 MGD (14.5 MGD of Chandigarh share and 1.5 MGD of Panchkula share per phase). These two phases are expected to be commissioned by 2011. Thus the total canal water supply available will be 103 MGD or 469.68 MLD.

2.1.2 Groundwater supply

In Chandigarh, the use of private tubewells has been banned. Groundwater for drinking water supply and for irrigation is being provided solely by the municipal corporation. Water is pumped from the deep aquifers below 100 m. There are a total of about 219 tubewells for both urban and rural areas, of which water from 200 tubewells is used for urban water supply. As groundwater has been used for water supply since the creation of the city, water table in the deeper aquifers have declined considerably.

MAP: **LOCATION OF DEEP TUBE WELLS**

Source: PH Department, MCC

2.2 WATER CONSUMPTION

2.2.1 Per capita supply

Given the total water available for supply at 87 MGD or 396.72 MLD and a total population of 12.97 lakh, the total per capita supply after allowing for 22 % leakage losses is 269.17 lpcd. The total domestic per capita supply after deducting 22% leakage loss is 140.53 lpcd.

Total per capita supply

Total water available for supply	= 396.72 MLD
Less: leakage losses	= 349.11 MLD
Total population	= 12.97 lakh
Total per capita supply	**= 269.17 lpcd**

Domestic per capita supply

Total water available for supply	= 396.72 MLD
Less: leakage losses	= 349.11 MLD
Less water for:	
Industrial & commercial	= 34.91 MLD
Institutional	= 43.95 MLD
Horticulture (3573 acres)	= 87.98 MLD
Water available for domestic water supply	= 182.27 MLD
Domestic per capita water supply	**= 140.53 lpcd**

2.2.2 Total water demand and supply - 2009

As per the population figures compiled by the Office of the Registrar General and Census Commissioner of India, New Delhi, Chandigarh's population was 12.97 lakh in 2009. Assuming domestic supply at 150 lpcd , and water for floating population at 5% of domestic demand, the total domestic water demand is 204 MLD.

TABLE: **DOMESTIC DEMAND**

Population in lakh (2009)*	12.97
Domestic demand @150 lpcd (MLD)	194.55
Floating population @ 5% of domestic demand (MLD)	9.73
Total domestic demand (MLD)	204.28

Note: *Registrar General and Census Commissioner of India

Details of water demand for industrial, commercial, institutional and horticulture are as follows:

TABLE: **OTHER DEMANDS**

Description	No of acres	Water demand gallons/acre/day	Total water demand MLD
Commercial & industrial	actuals		34.91
Institutional	actuals		43.95
Horticulture	3573.0	5400	87.98
Total			166.84
Add: Total domestic demand			204.28
Total demand in city			371.12
To add provision for distribution losses at 22%			81.65
Grand total demand			452.77
Demand in MGD at 4.56 MLD = 1 MGD			99.29

Source: PH Department, MCC

Total available for supply	= 87 MGD or 396.72 MLD
Total demand	= 99.29 MGD or 452.77 MLD
Demand/supply gap for 2009	**= 12.29 MGD or 56.05 MLD**

As can be seen from the table above, the total water demand in 2009 exceeds the water supply.

2.2.3 Measures to address the demand-supply gap

As there is no further scope of increasing canal supply water, there remain very few options for the Administration to address the existing and future demand-supply gap. There is a need to put in place systems for the following:

- Rainwater harvesting: Storage and recharge
- Recyle and reuse water, both at the centralised and at decentralised levels.
- Demand side management measures: Reduce demand through the use of water efficient fixtures, water conservation measures.

2.2.4 Measures that have been already initiated by the Chandigarh administration

Rainwater harvesting: The Administration has undertaken artificial recharge in a number of sites within the city. These structures have been designed by the Central Groundwater Board (CGWB).

- Central Scientific Instrument Organisation (CSIO) Complex, Chandigarh (1998-99): One of the earliest structures to be constructed, the site has been monitored for impact of artificial recharge on the groundwater level. The roof area of the building is 3550 sq m rainwater is recharged through injection wells. In 2000, as per water quality level monitored by CGWB, the site recorded an increase of 2m.
- Panjab University, Chandigarh (2001): The rooftop of the Basic Medical Sciences Block of 2100 sq m was used to harvest and recharge rainwater through a trench-cum-recharge well.
- Bhujal Bhawan Chandigarh (2001-02): The rooftop of the building was used to harvest and recharge rainwater through a trench-cum-recharge well.
- Other structures have been constructed at Leisure valley; Chandigarh Housing Board, Sector 9; DAV School, Sector-8; UT Guest House, Sector-6: Government College for Women, Sector-11; Public Health Office Building, Sector-11; Government College, Sector-46; and, Government College for Boys, Sector-11.

Recycle and reuse of water: Under the JNNURM, the MCC has already set in motion a process to treat and reuse sewage water for horticultural purposes. Chandigarh is unique because it has a huge demand for water for horticultural purposes. The total water demand for horticultural purposes is 87.98 MLD, which is 19.43% of total water demand and 43% of the total domestic demand. To reduce its pressure for fresh water, a tertiary treatment (TT) plant was set up in Diggian in 1991 of 10 MGD capacity. Here, sewage is treated to the tertiary level so that it can be used for horticultural purposes and pipelines have been laid to distribute this treated water for the green areas in Sectors 1-12 and Sector 26. At present 7 MGD of TT water is being distributed through piplelines to green areas in Sectors 1-12. Work is ongoing for laying of more pipes to distribute the remaining TT water of 3 MGD to more green areas.

Under JNNURM, a proposal has been approved to construct treatment plants to treat a further 10 MGD of sewage so that all the demand for horticulture can be met through the use of TT water. The break-up of the acreage of green areas is as follows:

TABLE: **GREEN AREAS**

Sector numbers	Area in acres
1-12, 26	1290
15-25 (Green areas + Houses with area of 1 kanal or above)	2283
Total	3573

Source: PH Department, MCC

Tertiary treated water required for 3573 acres (@ 5400 gallons/acre/day) = 19294200 Gallons; = 19.29 Million Gallons per day = 20 MGD

2.3 WATER TARIFF

The tariff structure is as follows:

TABLE: OTHER DEMANDS

Domestic		Non-domestic	
Consumption (m^3)	**Rate (Rs/ m^3)**	**Category**	**Rate (Rs/ m^3)**
1-15	1.75	Lawn/irrigation	2.50
15 – 30	3.50	Institutional	9.00
30 – 60	5.00	Semi-commercial	12.00
Above 60	6.00	Commercial	11.00

Source: PH Department, MCC

Consumers are billed every two months. The cost of a new domestic connection is Rs 530 for a half-inch connection payable prior to connection. About 79% of service connections are metered. Those not metered pay a monthly flat rate. The bulk water users are the Punjab University in sector 14, Postgraduate Institute of Medical Education & Research in sector 12 and CSIO in sector 30 C. The government colonies also receive bulk supply.

2.4 COST OF PRODUCTION

The total annual cost of production is approximately Rs. 75 crore. The annual production of water is approximately 144,80,2800 kl. The average cost of production of 1 kl of water is Rs. 5.18.

2.5 JNNURM PROJECTS

Chandigarh has three approved projects under JNNURM, relating to water supply.

- Conservation of drinking water by harvesting of the tertiary treated sewage for irrigation of green spaces in Chandigarh. (36.73 crore): This project is in process and at present 7 MGD of treated water is being supplied for horticultural purposes.
- Upgradation of water supply infrastructures for proper monitoring and automation with remote computerized surveillance system to 24x7 water supply. (Rs. 20.26 crore).
- Augmentation of water supply: The engineering wing of the MC has prepared the Detailed Project Report (DPR) of phase V and VI of the Kajauli water project. The total cost of the project is estimated at Rs 198 crore and is expected to be funded under the JNNURM programme.

3. Rainwater harvesting: proposal to augment water resources

3.1 WHY RAINWATER HARVESTING?

Rainwater harvesting must be undertaken on priority as Chandigarh does not have any surface water source and are declining. Water is being tapped from deep aquifers across the city. Tubewells are present in almost every sector of the city. As water is tapped from the confined deep aquifers, recharge will not happen naturally. As the city has very few options for sourcing water, recharging the confined aquifers from where water is being tapped becomes a necessity.

3.1.1 Water scarcity

Every summer, newspaper reports quote residents residing on the second and third floors in the southern sectors of the city complaining about the shortage of drinking water. Residents have also held a series of protests in several parts of the city. In 2009, Chandigarh was getting supply of 87 MGD per day against the requirement of 99.29 MGD.

3.1.2 Future demand

The water shortage is likely to get worse in the coming years as the population is already more than double the planned capacity for the city. In addition, there is a large floating population and a slum population that is being rehabilitated. There are plans for a number of new initiatives such as the Medi City, the IT park and other such projects that will swell the population of Chandigarh. The demand of water for other purposes such as industrial and commercial will also increase concurrently with the demand for domestic water demand.

HIGH AND DRY

Water scarcity leaves residents high and dry

CHANDIGARH: Water scarcity in the tricity at the beginning of summer season has left residents high and dry. In Chandigarh, the problem is more marked in the southern sectors where numerous housing societies are located. In many areas, residents have already started complaining of low water pressure.

Rakesh Sharma, who resides in a housing society in the southern part of the city, alleged those living on the top floors are not getting water at all. Raj Malhotra of Sector-37 said low water pressure is being witnessed on the first and second floors. Chandigarh MC officials said people living in housing societies should use additional connections to overcome these problems.

TNN, Apr 13, 2010

TABLE: **PROJECTED DOMESTIC DEMAND UP TO 2025**

Year	2011	2016	2025
Population in lakh *	14.38	17.8	24.88
Domestic demand @150 lpcd (MLD)	215.70	267.00	373.20
Floating population @ 5% of domestic demand (MLD)	10.79	13.35	18.66
Total domestic demand	226.49	280.35	391.86

Source: *Statistical Abstract, Chandigarh Administration website

TABLE: PROJECTED DEMAND FOR OTHER PURPOSES UPTO 2025

Year	2011	2016	2025
Commercial & industrial (No. of acres)	1921.63	1998.50	2161.60
Demand (@4000 gallons/acre/day) (MLD)	35.05	36.45	39.43
Institutional (No. of acres)	3048.50	3170.44	3429.15
Demand (@4000 gallons/acre/day) (MLD)	55.60	57.83	62.55
Horticulture (No. of acres)	3573.00	6600.00	6600.00
Demand (@5400 gallons/acre/day) (MLD)	87.98	162.52	162.52
Total demand (MLD)	178.64	256.80	264.49

Source: CDP, Chandigarh

TABLE: TOTAL PROJECTED DEMAND AND SUPPLY (DOMESTIC + OTHER PURPOSES) (MLD) UPTO 2025

Year	2011	2016	2025
Total domestic demand	226.49	280.35	391.86
Total demand for other purposes (MLD)	178.64	256.80	264.49
Provision for distribution losses @22% (MLD)	89.13	118.17	144.40
Grand Total demand (including losses) MLD	**494.25**	**655.32**	**800.75**
Supply (MLD)	**469.68**	**469.68**	**469.68**
Gap	**-24.57**	**-185.64**	**-331.07**

Source: CDP and PH division, MCC

3.1.3 Decline of groundwater

Chandigarh is already sourcing 22% of its water supply from groundwater and there is a considerable decline in the groundwater levels of the deep aquifers. According to CGWB pre monsoon data for the period 1991 to 2006 (15 years), Sector 10 in the north shows a maximum decline of 16m and in Sector 31, the fall has been of the order of 10m. The remaining parts of the city show on average a decline of 5 to 8 m. To cope up with the decline the municipality is drilling deeper. Every year about 10% of such tubewells become defunct (see Map: *Premonsoon groundwater level – deep and shallow*).

3.1.4 Limited augmentation options

The options for augmentation of sources of water supply for Chandigarh are very limited. Chandigarh is already sourcing its water from a distance of 27.5 kms from the Bhakra Main Line at Kajauli. As Kajauli is situated at a lower altitude than Chandigarh, water has to be pumped to Chandigarh, expending a great deal of financial resources. Chandigarh spends 60% of its total O & M cost on power.

Moreover, plans for further augmentation of water from Kajauli have run into problems as the Punjab government is reluctant to release any more water.

Uncertainty prevails over the MC's project to enhance Chandigarh's water supply as the Punjab government has refused to release water for Kajauli Phase V and VI.

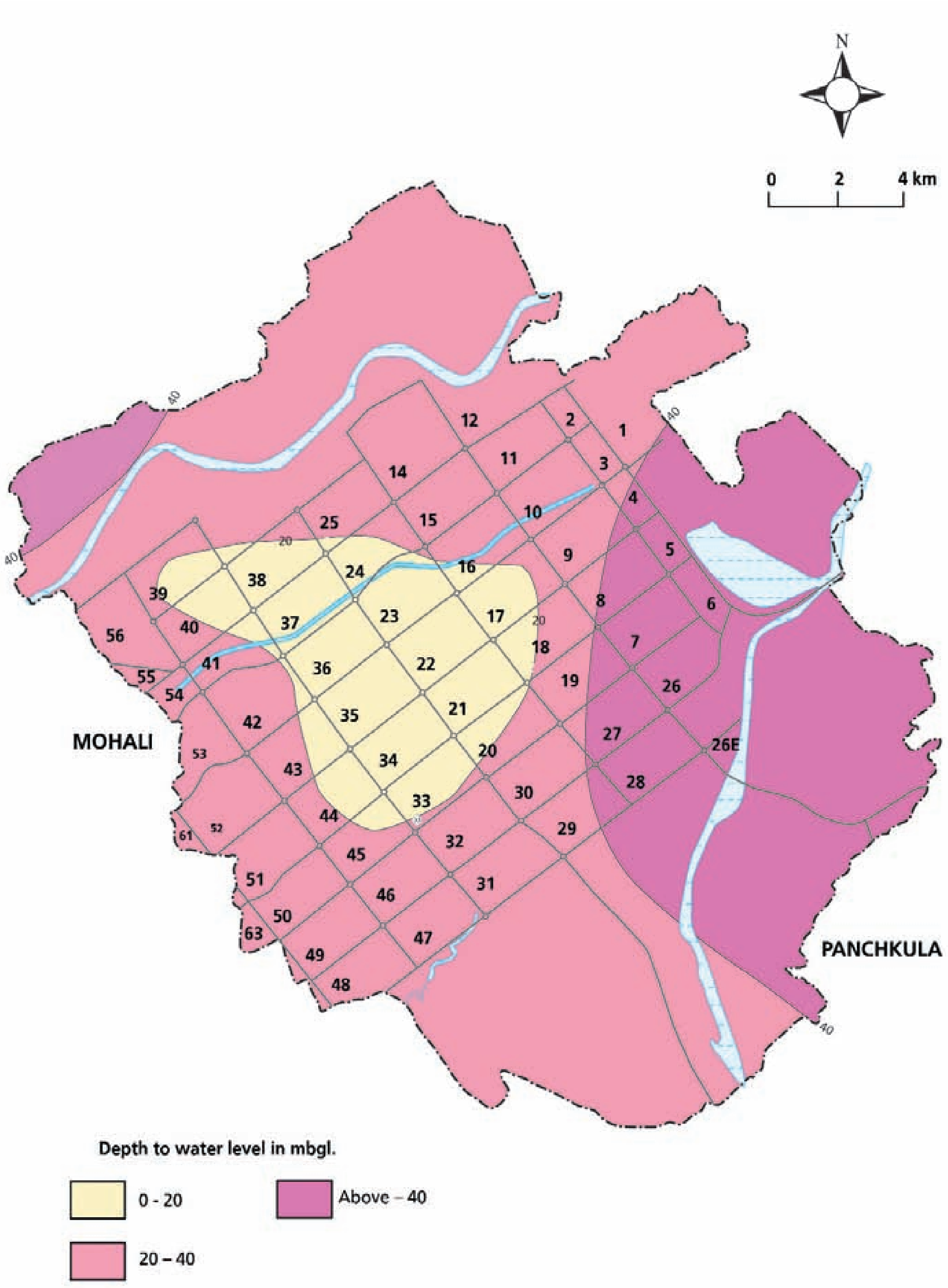
The MC had mooted Augmentation of Water Supply Scheme (Kajauli) Phase V and VI to augment the city's water supply by 40 million gallons per day (MGD). After giving Punjab and Haryana their share, the city will get 29 MGD water from the project. Recently, the Central government had approved around Rs. 130 crore for the scheme under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). But till the Punjab government releases the additional 40 MGD, progress on the scheme is not possible. According to MC officials, the Punjab government's argument against releasing the additional water is that "the city is already getting its fair share".

MC plan to augment supply in city blocked, Punjab says no to extra water

In order to settle the dispute among Punjab, Haryana and Chandigarh over the issue of Augmentation of Water Supply Scheme Phase V and VI, the Punjab and Haryana High Court has directed the Haryana government, the Executive Engineer of Chandi Mandir and the UT Adviser to hold a meeting.

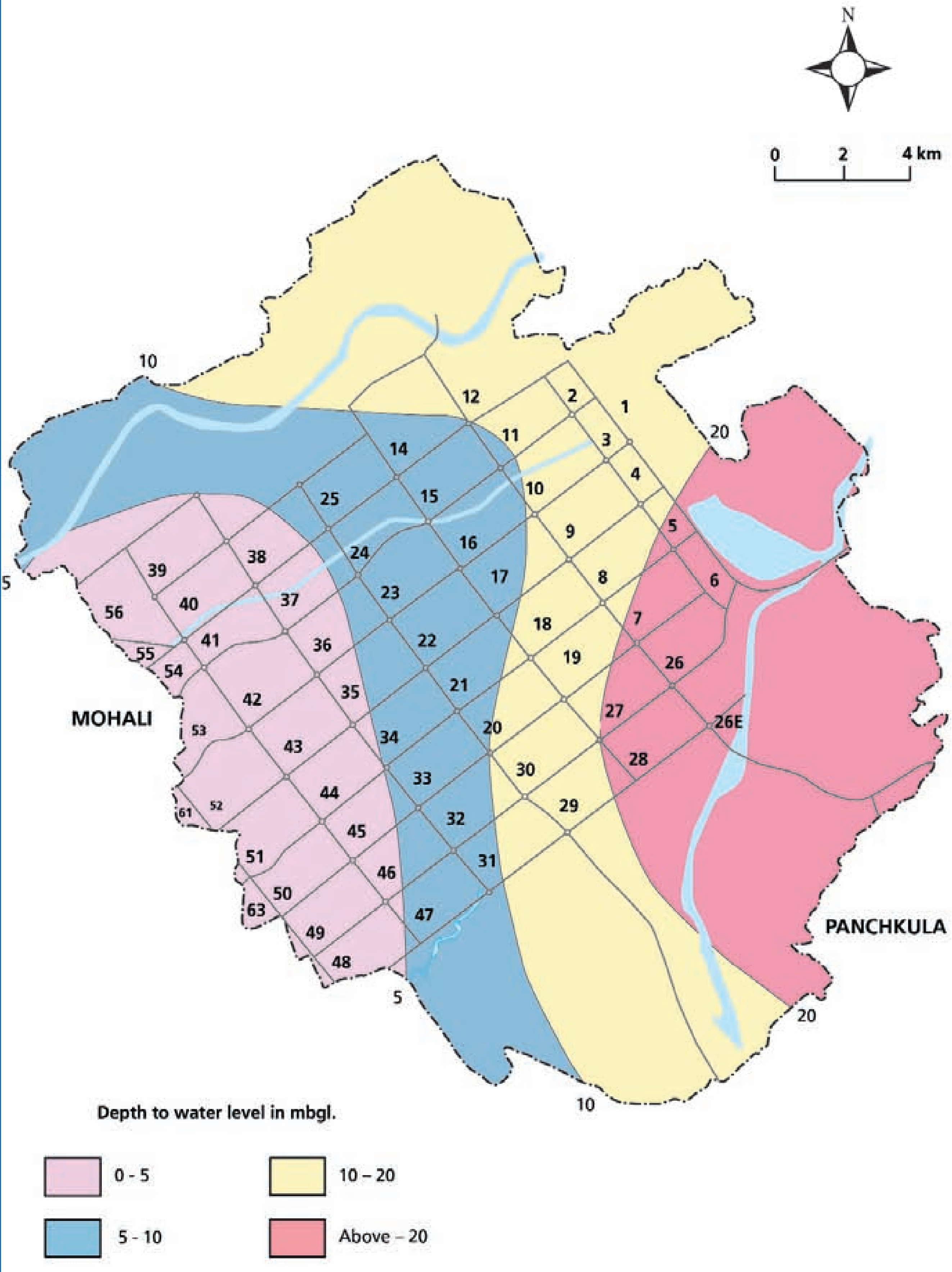
Indian express, Dec 17 2009,

MAP: **PREMONSOON GROUNDWATER LEVEL – DEEP AQUIFER**



Source: CGWB, Chandigarh

MAP: PREMONSOON GROUNDWATER LEVEL – SHALLOW AQUIFER



Source: CGWB, Chandigarh

3.1.5 Problems of flooding

Rainwater harvesting will also address the problem of flooding due to overloading of the storm water drains. The storm water drainage system has been designed keeping in view the slope of the city i.e. from northeast to southwest. It was initially designed for a rain intensity of half inch per hour. However, because of the increased green areas/ open spaces coming under construction, the run off co-efficient has increased tremendously. This has resulted in the over loading of storm water drainage system and hence flooding of low-lying pockets in the city. Although the Administration has augmented the capacity of the storm water drains by laying additional pipes, constructing rainwater harvesting structures along the storm water drains in the city will help to make use of the city's rain water endowment and at the same time address the problem of flooding during the monsoons.

3.2 RAINWATER HARVESTING FOR CHANDIGARH: PLANNING

3.2.1 Methodology

To identify the soil profile, integration of thematic layers have been done. These layers are derived from conventional methods through geographic information system (GIS) application. The thematic layers considered here are land use, geomorphology, geology, hydrogeology, storm water and sewage network.

The work on mapping is divided into three parts: (a) Collection of data; (b) Geo referencing of the maps and (c) Digitization

Collection of data: The basic land use map was supplied by the Chandigarh Administration. Other maps are collected from the existing research papers. Google-based satellite map has also been used for precise location of important locations like park/garden, important buildings like schools etc. Borehole logs have been collected to get an understanding of the soil profile below the surface.

Geo referencing of all maps: For the projection of map geographic latitude and longitudes are used with Datum Modified Everest. Software used for Geo referencing is Erdas Imagine 9.0.

Digitization: Reference maps once prepared in Erdas Imagine are transferred to Illustrator CS2 for final map work. Maps are prepared in different layers according to preferences of visibility. Boundary, street and scale were maintained in each map.

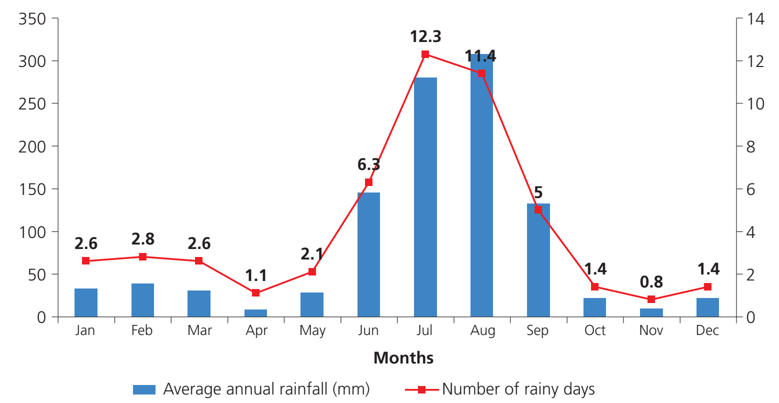
After the thematic layers are prepared, decisions about the solutions are taken to solve water crisis and the flooding problems according to the sites.

3.2.2 Parameters: Rainfall

Most of the rainfall is received during the months of July and August. The annual average rainfall of Chandigarh, based on long-term average between 1951-1980 is 1059.3 mm and the total number of rainy days is 49.8.

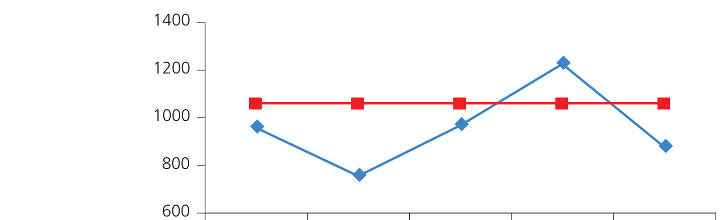
There is wide variation in rainfall as can be seen by the data given for the last 5 years. Rainfall has been below the annual average during four out of five years. Therefore, there is a need for capturing as much rain as possible.

GRAPH: AVERAGE OF 30 YEARS RAINFALL (1951-1980)



Source: http://www.imd.gov.in/section/climate/chandigarh2.htm

GRAPH: VARIATION IN RAINFALL FOR THE LAST FIVE YEARS



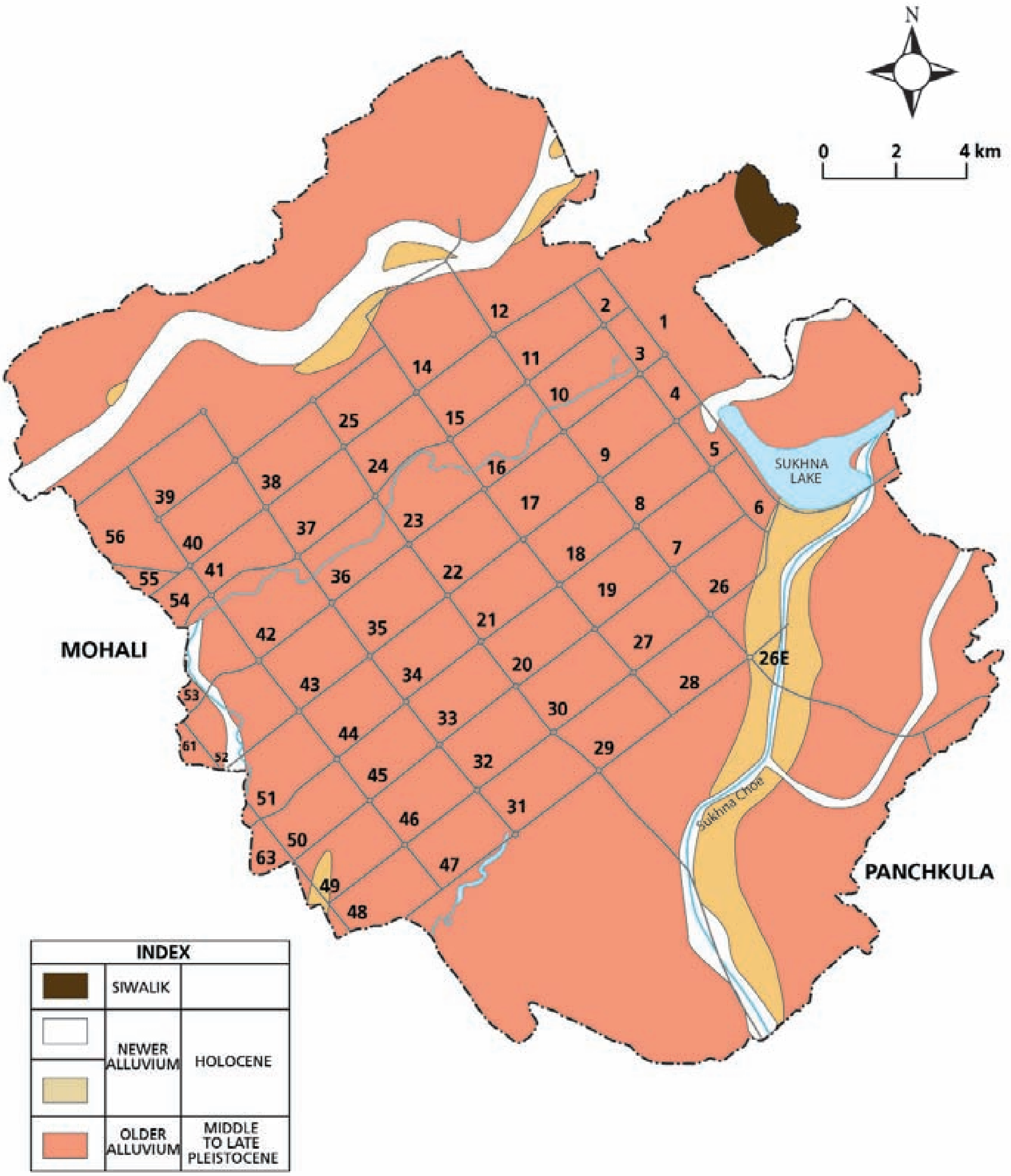
	2005	2006	2007	2008	2009
Actual Annual rainfall (mm)	956	754	968	1224	875
Average annual rainfall (mm)	1059	1059	1059	1059	1059

Source: India Meteorological Department (IMD), Chandigarh

3.2.3 Parameters: Geology, hydrogeology and soil

Geology: Quarternary sediments belonging to the Indo-Gangetic alluvium mainly cover the Union Territory of Chandigarh. The Older alluvium covers major part of the area and comprises layered sequence of clay, silty clay, and sand with lenses of pebbly sand and gravel. The younger Alluvium mainly consisting of light grey micaceous sand and pebbles with interbeds

MAP: **GEOLOGICAL MAP**

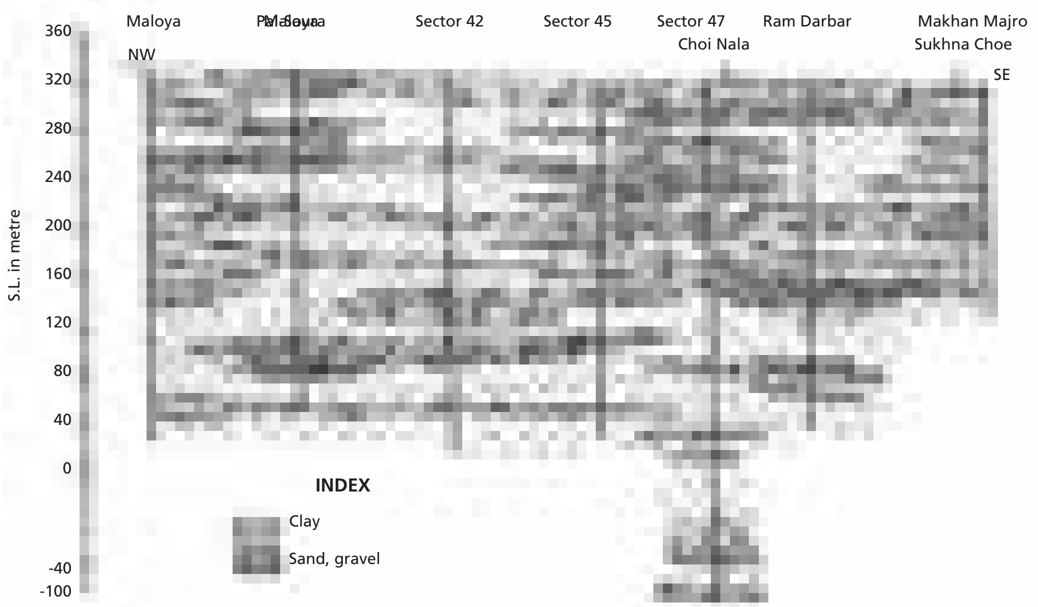


Source: Kandpal, G.C., *et al,* 2009. Geotechnical Studies in Relation to Seismic Microzonation of Union Territory of Chandigarh.J. Ind. Geophys. Union. Vol.13, No.2, pp.75-83.

of purple and red clay occur as recent flood plain deposits along river/nala courses, namely Patiali Rao and Sukhna Choe[2]. Based on the exploratory studies carried out by CGWB in the northern and southern parts, it has been inferred that the thickness of the coarser sediments is more in the northern parts of the city than in the southern parts.

Soils: The soil strata in general comprises of clayey silt soils in the top layers followed by sandy silt to silty sands at depths in most of the sectors. In northern parts the soil is sandy to sandy loam where as it is loamy to silt loam in southern parts.

FIGURE: SUB-SURFACE GEOLOGICAL FEATURES ALONG NW-SE



Source: Dharmaju, R., Ramakrishna, WGST., Karthigeyan, S. and Devi G. 2008. Liquefication potential of Chandigarh city—a conventional approach. 12th International conference on International Association for computer methods and advances in Geomechanics (IACMAG). pp 2804-2810.

According to a study conducted by G C Kandpal et al, 2009, there is wide spread distribution of clay, sand, pebbly sand and pebble layers in the area. The lithologs of boreholes drilled at Chandigarh reveal that there are interlayered sequences of clay and sand in most of the boreholes.

Hydrogeology: In Chandigarh, there are two distinct aquifer systems - shallow and deep. Water levels of the deeper aquifers are in the range of 15 to 70 metres below ground level (mbgl), those in the shallow unconfined aquifer are in the range of 2 to 17 mbgl. According to CGWB, a distinct aquifer of around 10-20 m thickness at a depth of about 160 m exists persistently all over the Union Territory (UT) area except southwestern parts[3].

The water levels are especially quite shallow in the south-western sectors. There is a hydraulic difference of 20 m between groundwater levels of northern and southwestern parts of the city. This causes the movement of groundwater from north to southwest. Due to this, natural recharge takes place in the shallow aquifer of the southwestern part of the city. Thus there is rise in the groundwater level in the southern and southwestern sectors. Flooding in these areas occur mainly due to this.

HYDROGEOLOGY IN A TYPICAL SECTOR

A representative borehole shows alternate layers of clay and sand. The topsoil is clayey followed by medium sand followed by alternate layers of clay and sand. Up to a depth of 135 feet or 41.15 metres, there is more of clay than sand. Between 135 feet and 210 feet below ground level (BGL), there are larger layers of sand. Recharge can be undertaken at these depths (between 41 and 64 metres BGL).

Source: Chandigarh Administration

Groundwater quality: The quality of groundwater is good and within the permissible limits prescribed by Bureau of Indian Standard (BIS) (1991) for drinking water based on tests undertaken by the Chandigarh Pollution Control Committee.

This study shows that levels of nitrate and iron is high in some of the locations where water samples were drawn from hand pumps that are about 15 m deep[4].

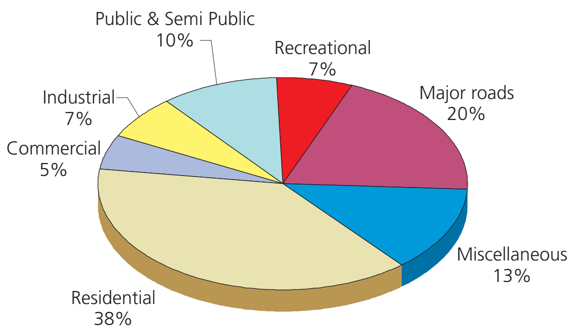
Water from shallow aquifer is not allowed for drinking purposes to avoid risk of bacteriological contamination. This is due to open defecation in the rural settlements and slum colonies in the northern-most parts of the city. As there is a hydraulic difference between the northern and the southern parts of the city, there is a risk that the contaminated water of the shallow aquifer will move downwards and contaminate the shallow aquifer of the city.

A study undertaken on the bacteriological contamination of hand pumps and tap water in peri-urban and slum areas in the northern part of Chandigarh showed contamination in over a third of the total samples due to open defecation. This study was undertaken over a period of two years (between 2002-2004, samples were taken from 133 handpumps and 107 taps)[5].

3.2.4 Parameters: Land use pattern

The total area of Chandigarh Union Territory is 114 sq km. Out of this about 79.44 sq km (70 % of the U.T.) belong to the urban area. The urban area has been categorized into seven categories. The residential area covers the maximum area which is about 30.19 sq km. The major roads also cover a substation area which is about 15.89 sq km. Green cover is well spread over the area of the city. Major institutions are planned in such a way that they occupy mostly the northern parts of the city.

GRAPH: LAND USE PATTERN OF URBAN AREA



Source: State of Environment, Chandigarh, 2008

The city has been divided into 56 sectors. Typically, each sector measures about 800 metres by 1200 metres, covering 250 acres of area. About 5000 to 25000 people stay or work in each sector. Every sector has a green strip oriented longitudinally. The strip is located centrally and used for sports and walk only. Heavy vehicles are not at all allowed in these green strips (see Map: *Land use pattern*).

In the master plan, ample area has been allotted for parks. The total area under horticulture is 3573 acres. The major parks are Leisure Valley, Rajendra park, Bougainvillea Park, Zakir Rose Garden, Shanti Kunj, Hibiscus Garden, Garden of Fragrance, Botanical Garden, Smriti Upavan, Topiary garden and Terraced Garden. The major institutions are located in sectors 10, 11, 12, 14 which are at the north of the city and sector 26 which is to the south of the city and 12.19 sq km has been allocated for institutional areas.

3.3 PLANNING FOR RAINWATER HARVESTING IN CHANDIGARH

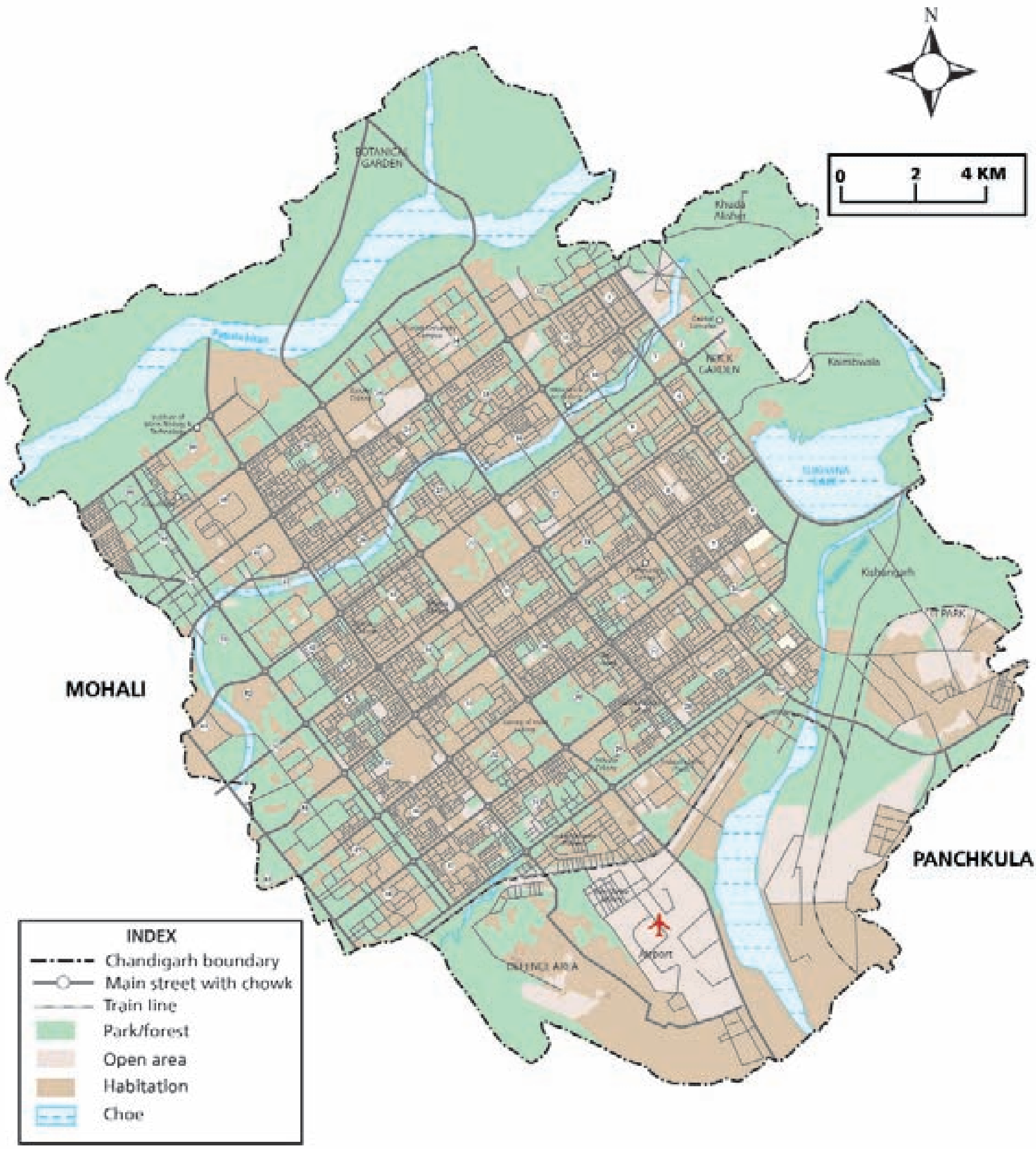
3.3.1 Rainwater harvesting potential

The rainwater harvesting potential of Chandigarh, with an area of 114 sq km, assuming a co-efficient of 50%, and the average annual rainfall of 1059.3 mm is 60380.1 million litres or 13241.25 MG or 36.28 MGD. This is more than the water pumped out of aquifers and therefore, harvesting and recharging rainwater will go a long way in contributing towards sustainability of water supply.

3.3.2 Catchment areas for rainwater harvesting

The Administration is tapping the deep aquifers for groundwater from all sectors in the city. Therefore, rainwater harvesting

MAP: **LAND USE PATTERN**



Source: Chandigarh Administration

can be undertaken to recharge the deep aquifers in the city. In order to do this, the sandy layers in the deep aquifers must be identified and recharge undertaken.

The areas suitable for rainwater harvesting are as follows:

1. Roads and roundabouts: Recharge along storm water drains to both recharge rainwater as well as prevent flooding.
2. All green areas: Recharge where suitable and store where hydrogeology is not suitable. Stored water can be used for horticulture. Ponds can be constructed to harvest and use rainwater as in Botanical Garden.
3. Institutional areas such as Punjab University, Capitol complex: Recharge where suitable and store where hydrogeology is not suitable. Stored water can be used for horticulture.

4. Commercial areas: Store in underground tanks for non-potable use.
5. Schools, colleges and religious places: Storage and recharge. Stored water can be used for horticulture and other non-potable uses.
6. Industrial areas and airport: Water from rooftop catchments to be stored that can be used for industrial purposes. Overflow of rooftop water can be recharged. Water from rooftops and hangars to be harvested in storage tanks to be used for non-potable purposes

Roads and roundabouts

The total land area for major roads is 22.8 sq km[5]. Recharge can be done either by constructing recharge trenches or recharge wells. Water from the storm water drain will be tapped and channeled into a desilting chamber from where it will be led into a recharge trench/well. The recharge bore will have slots for the sandy layers and will be blind in the clayey layers. As the water will be recharged into the aquifer directly, there is a need for good filtration systems. Annual desilting of the desilting chamber and cleaning of the filtration materials is mandatory to ensure that the system will be in good working order.

Detailed specification of desilting chamber and recharge trench/well is given in the next chapter.

Matka Chowk – Madhya Marg

Divider road between sectors 24 and 37

Crossing of divider between sector 24A & 25 and 14 & 15

Green areas

Although currently the MCC is supplying TT water for horticultural purposes, as per the City Development Plan (CDP), the city is planning for increase in horticultural areas. Currently, the total acerage of green areas including green areas in houses greater than 1 kanal is 3573 acres. The CDP planning has been done for 6600 acres. Therefore, the demand for treated water will also increase. The supply of treated water is expensive because, (1) cost of treatment to a tertiary level; (2) the water has to be pumped to the city as the treatment plant is situated at the lowest level. Therefore, rainwater harvesting can provide additional water at more economical costs.

Harvesting rainwater and storing in large ponds will ensure sustainable supply of water for green areas. Ponds can be constructed at the lowest elevation so that water flows to the pond by gravity. Chandigarh soil is suited to construct such ponds as the top soil is clayey. Recharge structures can be additionally constructed to channelise the overflow. For instance, the Botanical Garden has already constructed two such ponds.

General specifications for construction of rainwater harvesting pond:
Pond specification to harvest water from a green area of 1 acre (4047 sq m)
Assuming a collection efficiency of 25%, the rainwater harvesting potential will be
4047 x 1059.3 x 0.25 = 10.72 lakh litres.

To hold this water, a pond measuring 25 m x 11 m and a depth of 4 m can be built, that will have a capacity of 11 lakh litres. The sides of the walls can be strengthened by planting indigenous varieties of plants such as Vetiver, Apluda etc that will serve to hold the soil as well as help in arresting silt. Native species can also be planted in the channels leading to the pond to arrest silt.

Institutional areas

In the institutional areas, both storage and recharge can be undertaken because of the availability of large rooftop areas as well as paved and unpaved areas. Over or underground tanks can be constructed where rooftop water can be directed, filtered and stored. These can be used for non-potable purposes. Overflow of the water can be channelised into recharge structures. Recharge structures will be undertaken based on the nature of the aquifer geometry as per borehole logs.

Substantial water can be collected from large institutional buildings. For instance, the roof area of the Assembly building has an approximate roof area of 350 sq m. From this about 3 lakh litres can be harvested annually. Similarly, the High Court building in Sector 1 has an approximate roof area of 3600 sq m and approximately 30 lakh litres can be harvested annually. As there are large open spaces available around such public buildings, it would be feasible to construct underground tanks of a minimum capacity of 1 lakh litres to use for non-potable use.

Details of specification for construction of storage tank is given in Annexure II.

A MASSIVE PARK, FED ENTIRELY BY RAINWATER

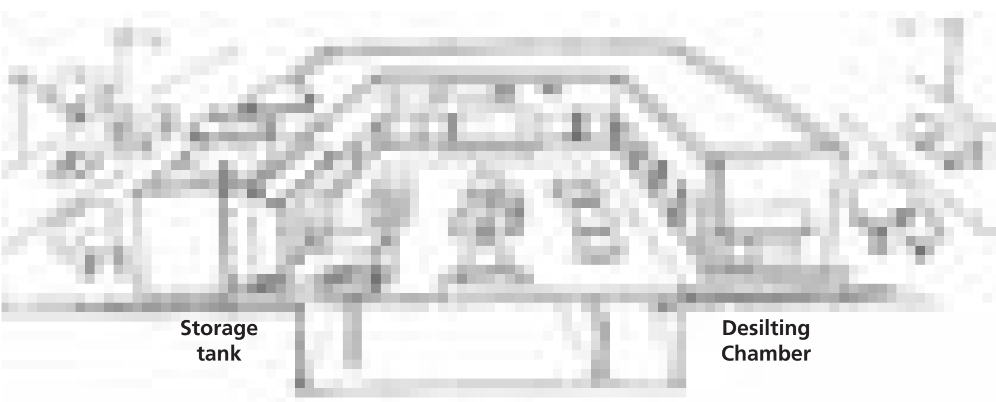
Five years ago, the Maharashtra Nature Park, near Dharavi, used to run up an annual municipal water bill of about Rs 3.5 lakh. Today, the park never pays more than Rs 4,000 a year. It has stopped using civic water entirely, except for 1,000 litres a day used for drinking. The total area of the park is 37 acres and the park needs about 1 crore litres of water every year. Rainwater is harvested also from the roof and paved area of the office building. The storage capacity of the pond is 2.25 crore litres, with an allowance of seepage of 15 lakh litres, 20-25 lakh litres for evaporation and dead stock of 30-40 lakh litres. The overflow from the pond is diverted to the Mithi river.

Hindustan Times, Mumbai, June 05, 2010

Commercial areas

Commercial areas in the city are planned in such a way that there are large spaces in front of the buildings that are used for parking. The rooftops of the commercial areas can be used to harvest a good amount of water. Large tanks of a minimum of 1 lakh litre capacity can be constructed in front of the commercial spaces under the parking areas as described above. This water can be used for non-potable purposes. The total commercial space as per land use records is 3.97 sq km.

FIGURE: **COMMERCIAL CENTRE, SECTOR 24**



Example: Sector 24

Total commercial area	= 30000 sq m
5% of total area as rooftop area	= 1500 sq m
RWH potential	= 12.71 lakh litres

Source: CSE

Schools, colleges and religious places

Schools and colleges have large rooftop areas from where it is easy to harvest rainwater and store it for non-potable use. Large tanks of a minimum of 1 lakh litre capacity can be constructed for non-potable use. The overflow can be used to recharge groundwater. Water from paved and unpaved areas can also be used for recharging.

Industrial areas and airport

Here, rooftop areas can be used for harvesting water that can be either stored or recharged.

3.3.3 Storage and recharge options

Rainwater harvesting can be done either by storing the harvested rainwater or by recharging the aquifer. In Chandigarh, rainwater harvesting is constrained by the following factors:

- Hydrogeological profile consists of layers of clay and sand in different thicknesses. This layered sequence compels finding the intervening sand lenses for recharge. The MCC is using only water from deep, confined aquifers, which do not get recharged naturally.

- The MCC is not using the shallow unconfined aquifer. As there is a steep incline from northern to southern sectors, the shallow unconfined aquifer in the southern sectors get recharged naturally and there is water logging in the monsoon season in these areas. Therefore, rainwater harvesting by recharge to the shallow aquifer cannot be undertaken. Rainwater harvesting by recharge can only be undertaken to the deep, confined aquifers.

- In terms of storage, as the number of rainy days are only 49 days, it is not possible to collect rainwater in storage systems that can be used for a longer period.

Where can you do storage and where recharge ?

Recharge: Recharge to deep aquifers can be undertaken in a number of areas across the city – from roads to green areas to airports. The storm water drain network is the most suitable for this purpose, as rainwater from the entire city is tapped for recharge.

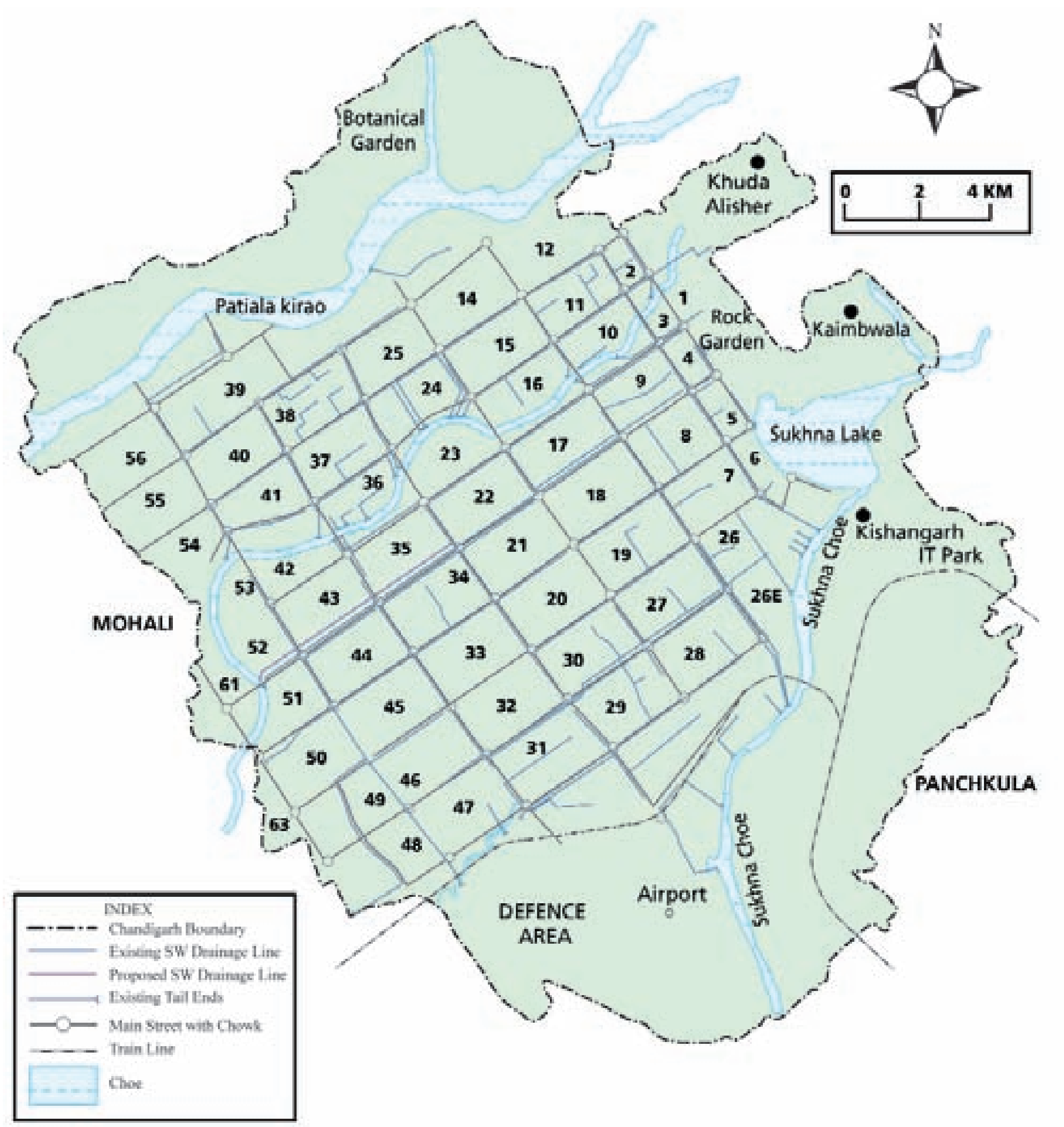
Storage: Storage in underground or over the ground tanks can be undertaken in the commercial areas, institutional areas like schools, colleges and other institutions, which have large roof areas. Storage can also be undertaken in green areas of Chandigarh by constructing ponds and larger water bodies. The soil is also suitable to create such water bodies. There are already such rainwater harvesting ponds in some of the green areas and more such bodies can be created and the water can be used for horticulture.

4. Planning for rainwater harvesting using storm water drains

4.1 STORM WATER DRAIN NETWORK OF CHANDIGARH

The storm water drains in the city are connected to the Sukhna choe and the N-choe. The tail ends of the drains have been constructed along the choe. The total length of the storm water sewer and its branch water sewer has been estimated to be 720 km.

MAP: **STORM WATER DRAINAGE SYSTEM**



Source: Chandigarh Administration

4.2 WHY RAINWATER HARVESTING THROUGH STORM WATER DRAIN NETWORK?

Chandigarh has a well laid out system of storm water drain network that is covered. Therefore, unlike other cities, there is very little pollution of storm water drains. In recent years, this network has been strengthened and augmented. More than 70% of the rain that falls on Chandigarh goes into the storm water drains.

Residential areas	–	38%
Roads	–	20%
Public and institutional buildings	–	10%
Commercial area	–	5%

Therefore, storm water drains can be tapped to capture a major portion of the rain that falls on the city. Recharge of water from the storm water drains will not only tackle the groundwater decline but also solve the flooding problems in the area.

4.3 METHODOLOGY OF RAINWATER HARVESTING IN THE STORM WATER DRAIN NETWORK

Recharge structures can be constructed along the roads and roundabouts to tap the water flowing in the storm water drains. The structures must be constructed in a way that they reach the sandy layers of deep aquifers.

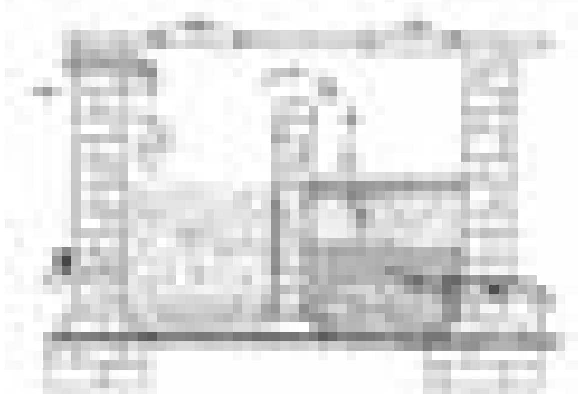
4.4 STRUCTURE OF A TYPICAL RECHARGE SYSTEM

A typical recharge system will consist of a desilting chamber and a recharge well/trench.

4.3.1 Desilting chamber

The desilting chamber will be 1 m long, 1 m wide and 1 m deep in size. This is provided to arrest silt as the drain also carries surface runoff from the surrounding areas. A baffle wall can be constructed in the storm drain to check the flow of the water and then diverted into desilting chamber. It is divided into two halves by constructing a baffle wall in the middle across the length. The first half of the desilting chamber will reduce the velocity of water and ensure the settling down of the silt and suspended materials in first chamber. After being filtered through this layer, water will pass into the recharge well or trench where it will undergo further filtration.

FIGURE: **CROSS SECTION OF A TYPICAL DESILTING CHAMBER**



Source: CSE

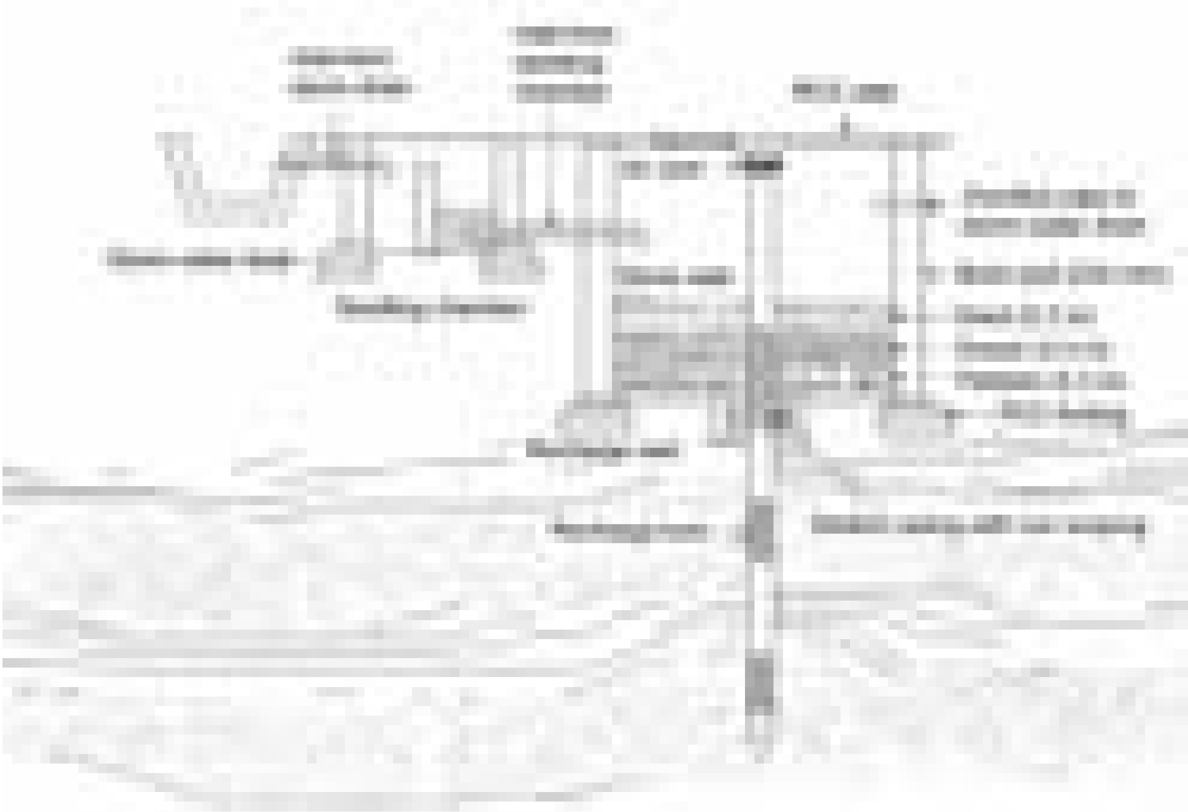
The second half of the desilting chamber has filtering materials filled up to half the depth of the tank, which is 1 m. There will be three layers of filtration materials – sand, pebble and gravel, each layer measuring 15 cm. The top layer of sand will be covered with a thin layer (5cm) of pebble to prevent scouring of sand. At the bottom of this portion of the chamber (0.4 m from the base) there will a slotted pipe (6 inches diameter) that will collect the filtered water and take it into recharge well.

The desilting chamber will also be provided with an arrangement for draining off the water standing in settlement tank after rains. For this purpose, a pipe fitted with tap or valve should be provided at the bottom of the chamber.

4.3.2 Recharge well with desilting chamber

The recharge well is 1.5 m x 1 m x 2 m in size. The well is constructed with brickwork and has a recharge bore of 150 mm diameter and a minimum depth of 60 m. However, the actual depth of the bore will depend on the soil profile of that area. The recharge bore will be drilled with mechanical bore set (down the hole (DTH) rig) and PVC pipe will be used as casing only in the upper portion where loose soil and other collapsible strata is found. A length of 0.6 m casing pipe in the recharge well will be slotted which will facilitate the movement of filtered water into the recharge well and later to the subsoil strata. The slots will be of 15-20 mm diameter and will be closely wrapped with jute coir of diameter 20 mm. This will prevent the direct entry of fine silt into the recharge bore. The pipe passes through both permeable and impermeable layers of the deeper aquifers. The recharge bore is slotted in the sandy layers and blind where there are clayey layers. The exact depth where the slots will be made will be based on the data from the borehole log that will show where the sandy layers occur.

FIGURE: **CROSS SECTION OF RECHARGE WELL WITH DESILTING CHAMBER**



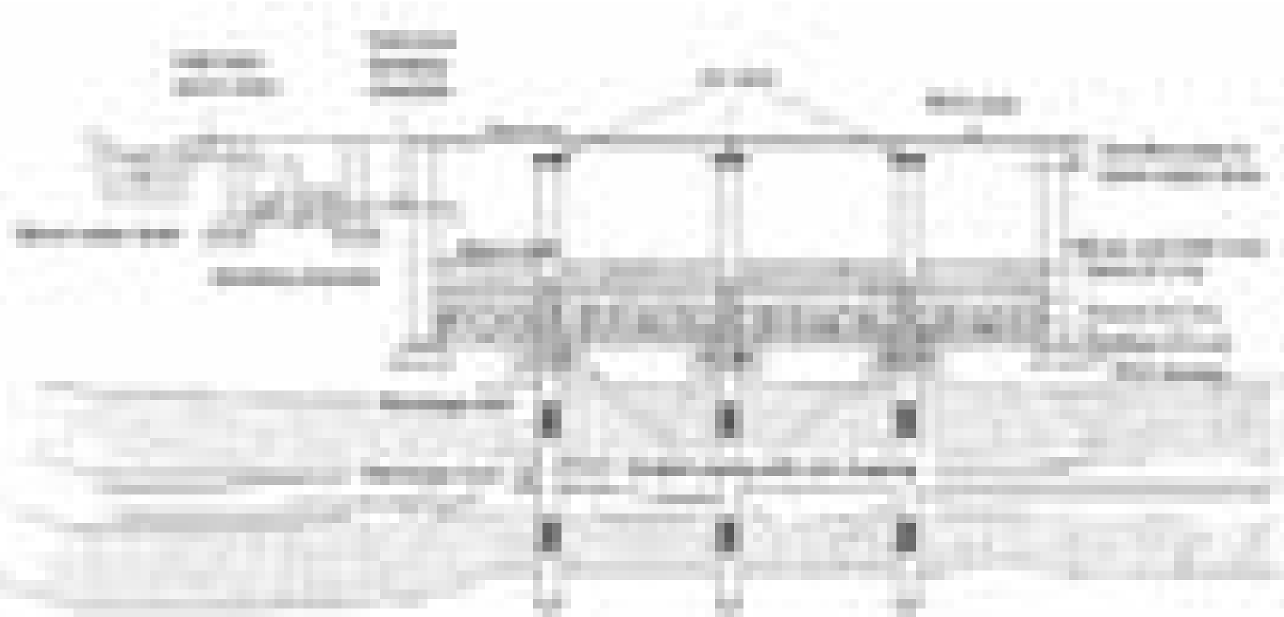
Source: CSE

4.3.3 Recharge trench with desilting chamber

The collected rainwater from the drain is first diverted into a desilting chamber first as described above. The recharge trench is 5 m x 1 m x 2 m in size. The trench is constructed with brickwork and has a recharge bore of 150 mm diameter. Each trench will contain recharge bores.

The recharge bores will be made as per specifications described above.

FIGURE: **CROSS SECTION OF RECHARGE TRENCH WITH DESILTING CHAMBER**

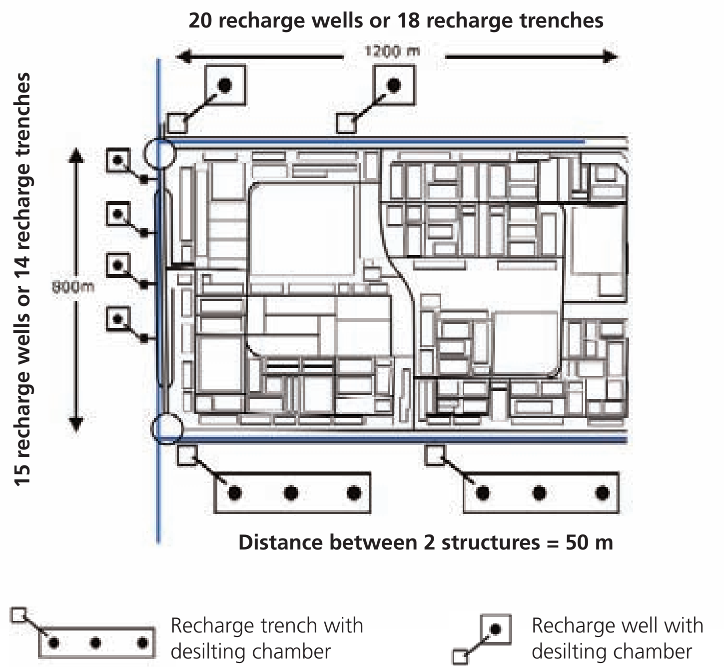


Source: CSE

4.4 LOCATION OF STRUCTURES

The periphery of a typical sector measures 1200 m x 800 m. Storm water drains run on either three or all four sides of the sector. Recharge structures can be built at intervals of 50 m.

FIGURE: **SITING OF RECHARGE STRUCTURES IN SECTOR 20**



Source: CSE

4.4.1 No of recharge wells around a typical sector

Length of the sector	= 1200 m
Length of desilting chamber	= 1 m
Length of recharge well	= 1.5 m
Intervening space	= 0.5 m
Total length of structure	= 3 m
Distance between two structures	= 50 m

No of possible structures along the length of a sector = 22 rounded to 20

Width of the sector	= 800 m
Length of desilting chamber	= 1 m
Length of recharge well	= 1.5 m
Intervening space	= 0.5 m
Total length of structure	= 3 m
Distance between two structures	= 50 m
No of possible structures along the width of a sector	= 15

Possible number of recharge wells on a typical sector with storm water drain pipes on 3 sides = 55
Possible number of recharge wells on a typical sector with storm water drain pipes on 4 sides = 70

No of recharge trenches around a typical sector
The length of a trench is 5 m and the length of a desilting chamber is 1 m. Allowance for distance between desilting chamber and recharge trench is 1m. Total of 7 m

No of possible structures along the length of a sector = 20 rounded to 18
No of possible structures along the width of a sector = 14

Possible number of recharge trench on a typical sector with storm water drain pipes on 3 sides = 50
Possible number of recharge wells on a typical sector with storm water drain pipes on 4 sides = 64

5. Costing of structures

5.1 COST OF A TYPICAL RECHARGE WELL WITH DESILTING CHAMBER

Costing has based on Delhi schedule rates.

Desilting chamber (Dimensions: 1 m x 1 m x 1 m)

TABLE: **COST OF A DESILTING CHAMBER**

Item of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Excavation	4.99	Cu m	90	449
PCC	0.10	Cu m	2700	279
Brick lining including baffle wall	1.3455	Cu m	1650	2220
RCC slab/metal grill	0.21	L.S.	4700	1002
Pebbles		L.S.		500
Total cost				**4451**

Recharge well: (Dimensions: 1.5 m x 1 m x 2 m)

TABLE: **COST OF A RECHARGE WELL**

Item of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Excavation	11.09	Cu.m	90	998
PCC	0.12	Cu m	2700	311
Brick work	2.65	Cu.m	1650	4364
100 mm thick RCC slab (1:2:4)	0.29	Cu m	4700	1345
Drilling (6 inch bore using hand bore set)	60	M	250	15000
6 inch PVC casing pipe	60	M	230	13800
Brickbats pebbles, sand and coir packing		L.S.		2500
Total cost				**38318**

Total cost of 1 recharge well with desilting chamber = Rs. 40437 or 40500/=

5.2 COST OF TYPICAL RECHARGE TRENCH WITH DESILTING TANK

Desilting chamber (Dimensions: 1 m x 1 m x 1 m)

TABLE: **COST OF A DESILTING CHAMBER**

Item of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Excavation	4.99	Cu m	90	449
PCC	0.10	Cu m	2700	279
Brick lining including baffle wall	1.3455	Cu m	1650	2220
RCC slab/metal grill	0.21	L.S.	4700	1002
Pebbles		L.S.		500
Total cost				**4451**

Recharge trench: (Dimensions: 5 m x 1 m x 2 m)

TABLE: **COST OF A RECHARGE TRENCH**

Item of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Excavation	26.87	Cu.m	90	2418
PCC	0.28	Cu m	2700	745
Brick work	6.35	Cu.m	1650	10474
100 mm thick RCC slab (1:2:4)	0.80	Cu m	4700	3747
Drilling 6 inch bore using hand bore set for 3 recharge bores	60	M	250	15000
6 inch PVC casing pipe	60	M	230	13800
Brickbats pebbles, sand and coir packing		L.S.		2500
Total cost				48684

Total cost of a recharge trench with desilting chamber = Rs. 53135

5.3 COSTS FOR RECHARGE STRUCTURES FOR A TYPICAL SECTOR

TABLE: **COSTS FOR RECHARGE STRUCTURES FOR A TYPICAL SECTOR**

	No of recharge wells	Cost of recharge wells (Rs)	No of recharge trenches	Cost of recharge trenches (Rs)
Typical sector with drainpipes on 3 sides	55	55 x 40500 = 22,27,500	50	50 x 53135 = 25,56,750
Typical sector with drainpipes on 4 sides	70	70 x 40500 = 28,35,000	64	64 x 53135 = 34,00640

If we take an average of Rs. 25 lakh for a sector, the total cost for 56 sectors would be Rs. 1400 lakh (14 crore). The annual maintenance cost arises only from cleaning of the desilting and cleaning of filter materials.

5.3.1 Impact of rainwater harvesting

The stormwater network collects water from the roads (15.89 sq. km), from rooftops of residential areas, (30.19 sq.km) from shopping areas (3.97 sq. km), public and institutional buildings (7.94 sq. km). This amounts to more than 70% of the total land area. The total quantum of water that would be available for recharge annually would be

58 sq km (area) x 1059.3 (rainfall) x 0.5 (rainfall coefficient) = 30720 million litres.(18.46MGD)

This is equivalent to almost 90% of the total groundwater supply and this is available only from tapping the stormwater drain network. By careful planning of recharge in the parks and green areas of the city, it would be possible to recharge the entire groundwater the city takes out.

6. Water for all: today and tomorrow

Against the background of the envisaged economic growth and the resulting population growth, the water needs of Chandigarh will grow at an explosive rate. But water availability will not grow in parallel leading to water stress and resultant conflicts. There is a need to put in place a number of measures to create awareness among the people about the importance of water and incentivise them to use water carefully and wisely. These will include policy measures (legal, financial), research, capacity building and education measures. Water conservation measures include: (a) Rainwater harvesting; (b) Recycle and reuse of water; and, (c) Reducing water use.

6.1 TOWARDS A WATER-SMART CITY: INSTITUTIONAL MEASURES

Step 1: Create a central authority to coordinate all water conservation and augmentation measures (Rainwater Harvesting or Water Conservation Cell).

Step 2: Define clear and definite short-term and long-term measures and targets, identify funding sources and secure adequate funding. Bulk users and institutional buildings must be targeted first.

Short-term measures: These include legal, administrative and financial measures on the one hand, and awareness creation and capacity building on the other. They go hand in hand and must be initiated together.

Long-term measures: A focussed programme to encourage research on such issues as hydrogeological and rainfall mapping, filters, technological tools must be instituted. Detailed maps of each zone can be created for recharge zones, flood-prone areas, water quality and water bodies that can be revived etc. Detailed studies can be initiated using GIS, satellite imageries.

6.1.1 Rainwater harvesting

Rain Centre: The first step to encourage rainwater harvesting in the city is to create a Rain Centre that will serve as a central repository of information on all aspects related to rainwater harvesting. The Rain Centre will have posters, models, and training facilities. It will be staffed with technical experts to provide technical help to common people. The Rain Centre will also serve as a centre for providing training and capacity building to a cross-section of people from masons and plumbers to consultants and architects.

The Rain Centre will be responsible for regularly conducting awareness creation activities on the need for water conservation and ways of doing it. This can be in the form of posters, exhibitions, events on special days such as World Water Day etc, competitions, quiz programmes, media campaigns, etc. The target groups will be residents Welfare Associations, school children, industries, institutions etc.

The Rain Centre will also prepare and make available a database of implementers (plumbers, masons, contractors, architects, consultants), a database of best practices, information on techniques and costs etc.

Legal, administrative and fiscal measures: the Administration has taken the first step of making rainwater harvesting mandatory for houses of more than 1 kanal area. The notification only mentions “recharge” and this should be expanded to include storage options. Other mandatory measures must include the use of water efficient fixtures such as low flush toilets, water efficient fixtures etc. Pricing of water is a key instrument to ensure that consumers use water carefully. Measures to incentivise and motivate people include awards, reduction in water bills, rebate on property tax, quick passing of building plans etc.

A key system that must be set up will be an Inspection and Maintenance programme to ensure that all rainwater harvesting systems are kept in good order. A systematic programme to regularly clean and maintain the systems must be put in place.

Before exhorting the public to use water wisely, the Administration must lead by example by instituting measures for wise use of water in its own buildings. Rainwater harvesting must be implemented in all government buildings and public spaces such as parks, stadia etc. As Chandigarh's soil is suitable for constructing water bodies, the MCC must plan for water bodies in green areas and particularly in the southwestern sectors, where there is water logging. Public and commercial buildings must be made to implement water conservation measures in a targeted manner.

6.1.2 Recycle and reuse of sewage

The Chandigarh Administration has an ongoing system to treat and reuse sewage for horticultural purposes. The sewage treatment plant (STP) in Chandigarh has been situated at the lowest point of the city at Diggian so that sewage flows by gravity to the STP. Therefore, the supply of treated sewage for horticultural purposes has to be pumped from this lowest point to the higher areas where green areas are situated. This will add to the financial burden of the consumers, as they have to pay for the cost of treatment as well as energized distribution.

Moreover, all the sewage generated is not being tapped by the sewerage system. This is evident by the polluted state of the N-choe. Newspaper reports show evidence of raw sewage being dumped by a number of residential colonies along the N-choe. The seasonal rivulet has been turned into a sewage drain and the matter has reached the Courts.

Against this background, using small, decentralised systems that treat the sewage to a stage that they can be used for horticultural purposes is an easy way to arrest the pollution of the N-choe. For instance, areas such as the Punjab University Campus, the Capitol Complex have adequate land available to locate decentralised sewage treatment plants that will treat up to tertiary level and can be used for horticultural purposes.

Pollution of N-choe

Based on newspaper reports on the pollution of the N-choe by untreated sewage, particularly from Kahjeri village, the Punjab and Haryana High court took suo moto notice and issued orders to the Chandigarh Administration to specify " the steps contemplated to improve the condition of the choe." In its reply to the Court, the Municipal Corporation said that it would construct a STP plant with a capacity of at least 15 million litres per day (MLD), at Kahjeri to avoid flow of sewerage water of nearby colonies of that area in Natural Choe (N-Choe) of the city. According to the Tribune, 14 MLD of sewage was being dumped into the N-choe at Kahjeri. Newspaper reports also say that untreated sewage is being let into the N-Choe from the VIP areas in Sector 3.

According to reports of the Chandigarh Pollution Control Committee (CPCC), the BOD figure for January 2010 shows that it varied from four mg\l in the Leisure valley, Sector 10 to 41 mg\l at the exit Point near Kajheri. Very importantly, the figures for Dissolved Oxygen (DO), during the same period fell to zero at the Exit Point near Kajheri while it was as high as 10.2 mg\l in the green lawns of the Rose Garden, Sector 16 — not fit even for basic marine life.

TABLE: **WATER QUALITY OF N-CHOE ON JANUARY 15, 2010**

Location	BOD (mg/l)	COD (mg/l)	DO (mg/l
Leisure Valley	4	33	3
Rose Garden	3	25	10.2
Sector 23	6	41	1.5

Source: Tribune, April 6, 2010

6.1. 3 Water efficient fixtures

There have been technological innovations in many of the water fixtures with the aim of reducing water consumption. Some of the most common fixtures that have improved efficiencies of use are:

Flush toilets: Low flush toilets use 6 litres per flush as against 14-15 litres of conventional flush toilets and Ultra low-flush toilets use 3 litres per flush. There are also dual flush toilets that use between 3 to 6 litres per flush depending on half or full flush. The savings in water use can be up to 40-50% by switching over to low flush toilets. More than one-third of total water use is used for toilet flushing in urban centers. Switching to water efficient flush toilets will make a great impact on the total water consumed in urban buildings.

Urinals: There is an ongoing process of technological improvements to make urinals more water efficient or completely waterless. Several types of water efficient and waterless urinals are being developed as pilot projects.

Water efficient faucets and showerheads: Conventional faucets have a flow rate of about approximately 11-19 litres per minute (LPM) and water efficient faucets have a flow rate of 7.5 lpm. Installation of pressure reducing devices such as aerators can reduce the flow further. In addition, there are sensor taps that automatically shut off. One of the simplest way to improve efficiency is to switch from compression types faucets which require you to turn the faucet to open or close the taps to cartridge type faucets that require you to turn the handle in an up and down or lateral movement. There are also self-closing faucets which will automatically close after a set time to reduce the potential for taps to be left running too long or not turned off. Today there are a variety of products available that can be attached to existing taps to reduce water flow.

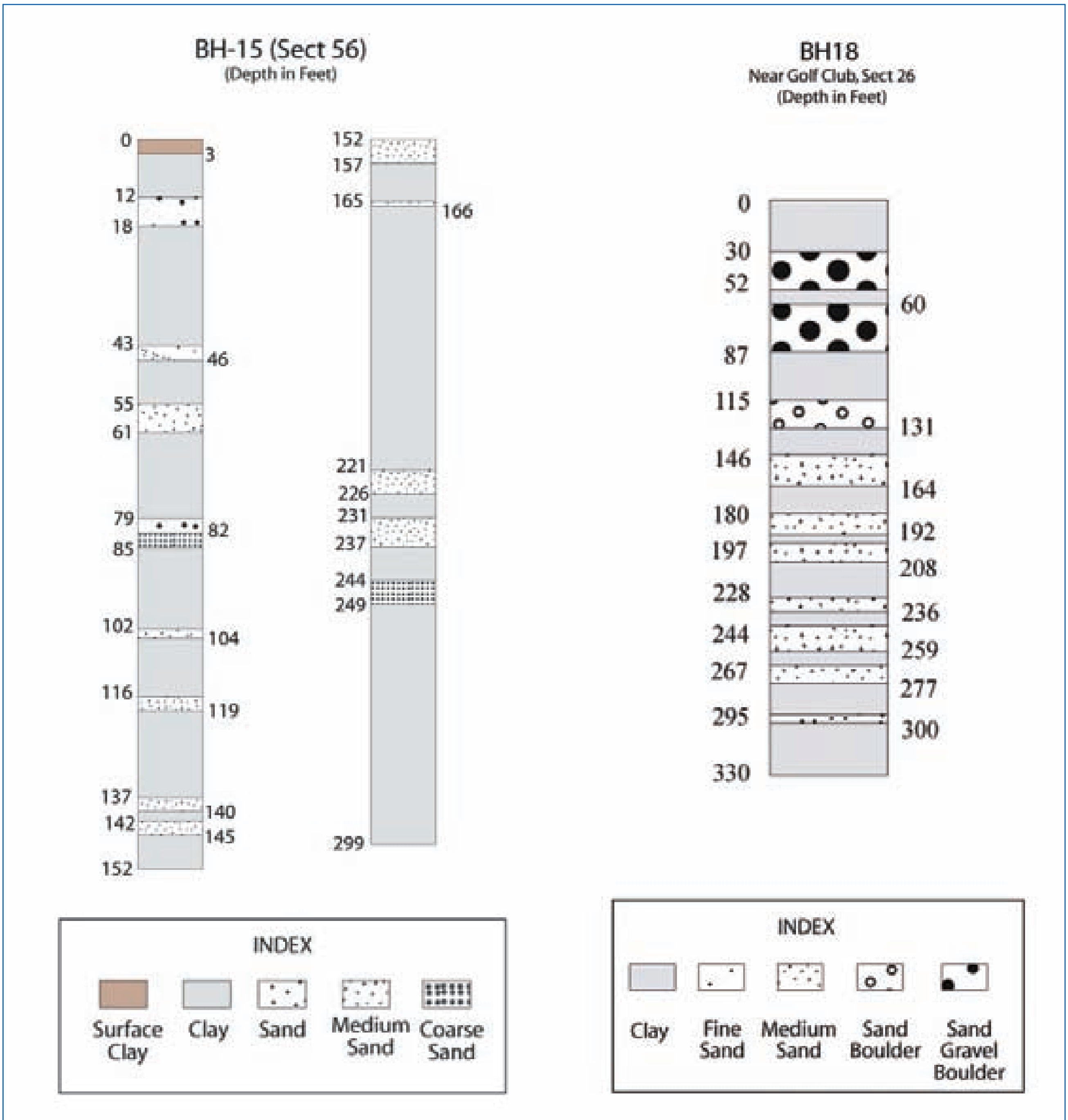
Washing Machines: In general, front loading washing machines are much more water efficient than top-loading machines.

Incentives and disincentives: The Administration must have a phased programnme to replace old flush toilets and faucets with new low-flush toilets and water efficient taps. This must be phased in through rebates in prices and water bills and at then made mandatory. To begin with public institutional buildings and large commercial buildings such as malls must be targeted.

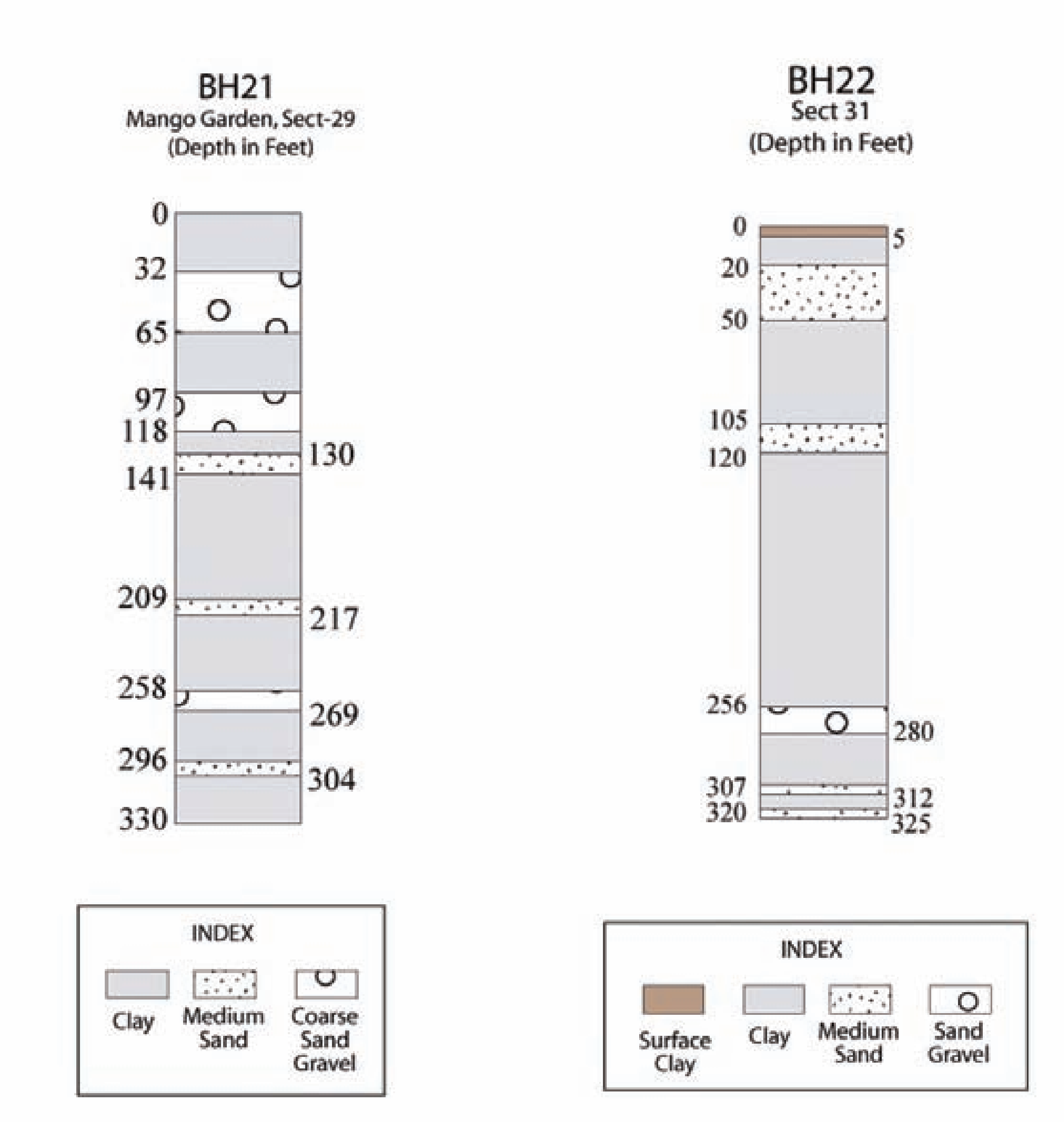
Currently the Ministry of Urban development is undertaking a study to initiate a programme of labelling of water efficient fixtures similar to the star rating system for electrical appliances. This will greatly help in motivating consumers to switch over to the use of water efficient fixtures.

7. Annexures

ANNEX 1: Soil profiles of few representative sectors



Source: Chandigarh Administration



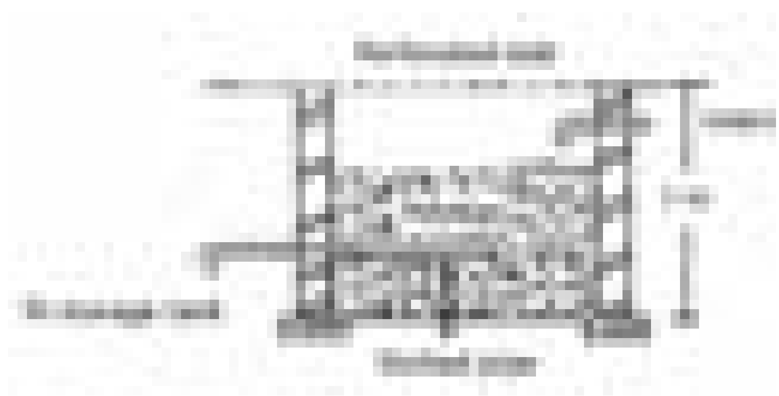
Source: Chandigarh Administration

ANNEX 2: Construction of brick masonry storage tank

The rainwater from the rainwater pipes is collected in series of collection chambers and using the polyvinyl chloride (PVC) pipes diverted into a filtering tank. The filtering tank will be of 1 m x 1 m x 1m in size, with unpaved bottom. This will be half filled with filtering material like pebbles. This will ensure the settling down of the silt and other suspended materials. The filtered water will be diverted into the tank. A diversion valve of suitable size should be fitted on the down take pipe for flushing the impurities coming down with initial spell of rainfall.

The tank is constructed as any other normal underground tank. The tank will be covered with a reinforced concrete cement (RCC) slab of 150 mm. Two pillars of 60 cm x 60 cm (with plinth foundation) can be provided across the length of tank for proper support of the roof. The slab will also have 2 manholes for cleaning and maintenance purpose. The tank will be provided cement & sand plaster with neat cement punning on all inner walls. All inlet pipes and over flow pipes will be covered with fine mosquito nets to avoid entry of insects inside the tank. The tank will also be provided with 2 air vents, covered with fine mosquito nets. The tank will be provided with a pump to lift the water into overhead tank. The tank will be of 1 lakh litres capacity. The water stored in this tank could be used for flushing the toilets and other purposes.

FIGURE: **FILTERING TANK**



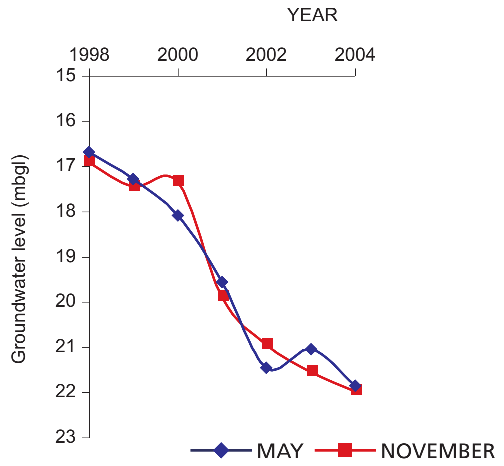
Source: CSE

ANNEX 3: Groundwater levels

GRAPH: GROUNDWATER LEVELS IN DEEP AQUIFERS

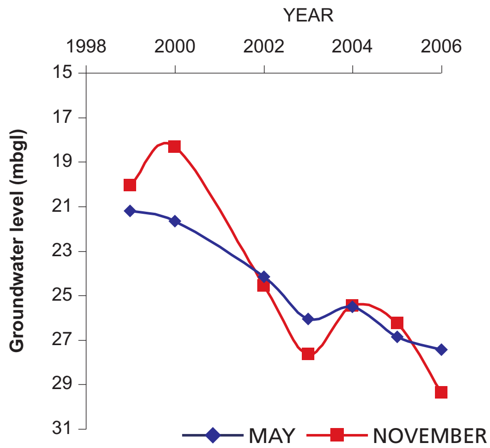
SEC 10 D

Approximately 5 m fall groundwater level of deep confined aquifer



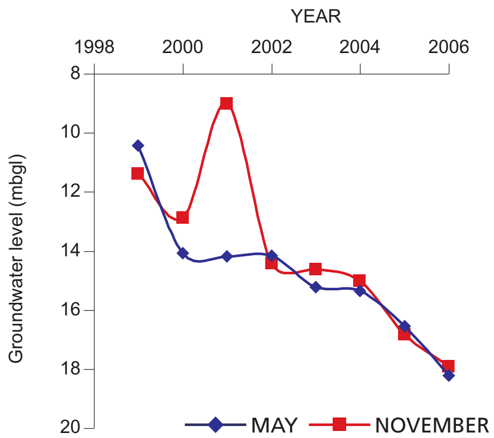
SEC 12 D

Approximately 6 m fall in the groundwater level of deep aquifer



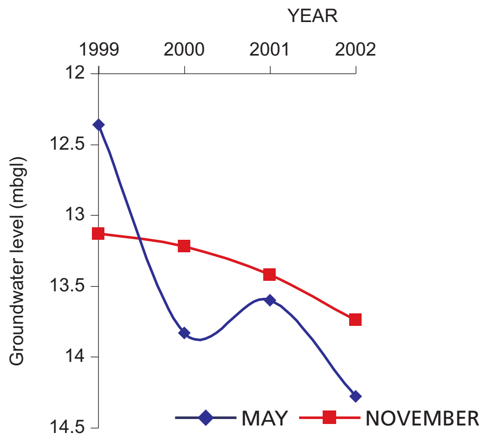
SEC 37 D

Approximately 8 m fall in the groundwater level of deep aquifer



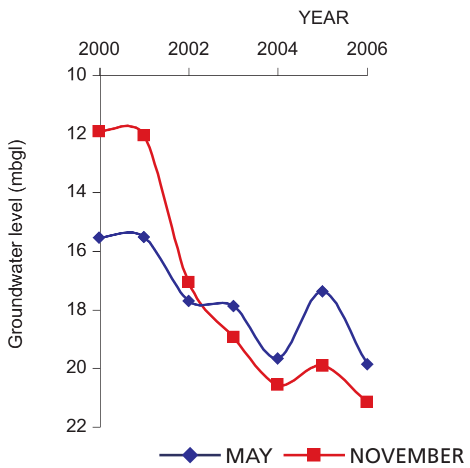
SEC 31 D

Approximately 2 m fall in the pre monsoon (May) groundwater level of deep aquifer



SEC 39 D

Approximately 4 m fall in the groundwater level of deep aquifer

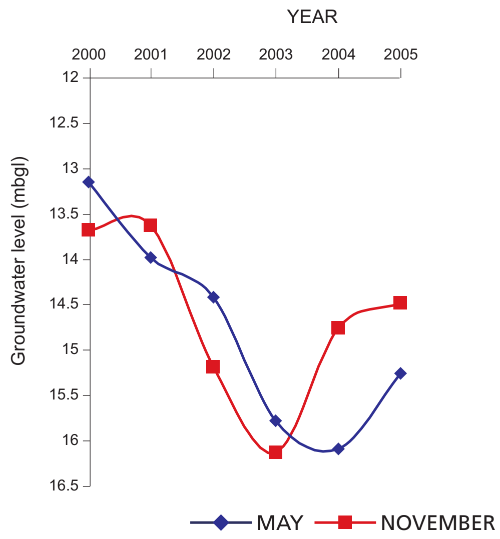


Source: National Data Centre, CGWB, Faridabad

GRAPH: GROUNDWATER LEVELS IN SHALLOW AQUIFERS

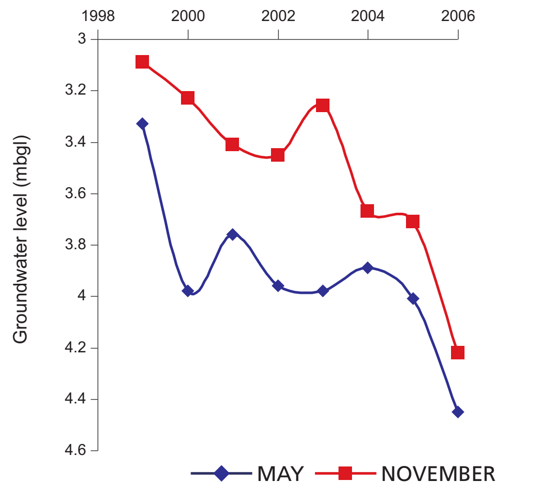
SEC 10 C

Approximately 2 m fall in the groundwater level of shallow aquifer



SEC 37 D

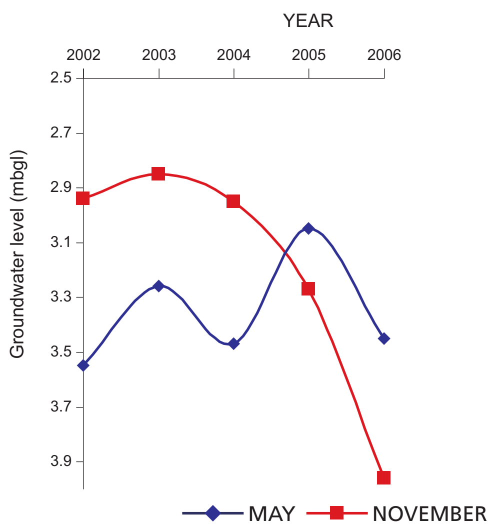
Approximately 1 m fall in the groundwater level of shallow aquifer.



RISE IN GROUNDWATER LEVEL IN SHALLOW AQUIFER

SEC 39 D

Approximately 0.1 m rise in the pre monsoon (May) groundwater level of shallow aquifer



Source: National Data Centre, CGWB, Faridabad

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Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Ph: 91-11-2995 6110 / 5124 / 6394 / 6399 **Fax:** 91-11-29955879
E-mail: cse@cseindia.org **Website:** www.cseindia.org