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Rain Water Harvesting & Conservation Manual 2019

CPWD

Director General, CPWD, New Delhi

RAIN WATER HARVESTING

&

CONSERVATION

MANUAL

2019

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Government of India

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FOREWORD

Shortage of water is a cause of deep concern throughout the world especially in developing and under developed countries. Water has become a very scarce resource. India is already experiencing severe water shortage and this problem will become very acute in the near future unless adequate preventive measures are taken on a gigantic scale.

Rain Water Harvesting and Conservation has become the necessity of time now. Although guidelines have been issued from time to time by various organizations, it is for the second time that the existing guidelines are revised and compiled at one place in the form of user Manual.

Government of India is giving great impetus for rain water harvesting and conservation. It has therefore been felt necessary that the officers of CPWD should also have easy and ready access to such guidelines issued by the Department/Ministry on this subject to enable them to take timely and appropriate action. The publication of this Manual will fulfill this important requirement.

This Manual is a result of combined efforts of a large number of officers. I would like to express my appreciation to Dr. K. M. Soni, ADG (Technical) and sincere efforts put in by his team comprising of Shri D. K. Garg, CE (D&DM), Shri N.K. Bansal, SE (D-II), Shri D.K. Das, EE (Tech.), Shri R.K. Gandhi, EE (D-VII), Shri Aakash Deep Sharma, EE (D-III), Shri Jai Prakash, AEE and Shri Suresh Sharma, Stenographer.

This Manual is one more step ahead on the path of engineering and technical excellence to which CPWD is perpetually committed.

(Prabhakar Singh)

Place: New Delhi
Dated: July 2019

सत्यमेव जयते

Dr. K.M. Soni
Addl. Director General (Tech)

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Nirman Bhawan, New Delhi

PREFACE

With the increasing trend of paving the soft areas in residential as well as non-residential structures, the open areas are getting reduced. This poses an adverse effect on the infiltration capacity of soil thereby adversely affecting the recharge of ground water which has depleted the aquifers. Due to surface water getting reduced, it is not enough to meet the demand and thus scarcity of water is prevailing in many parts of the country, hence there is an indispensable need to recharge the ground water. The rain water harvesting & water conservation have to be adopted on large scale.

Rain water harvesting can be done by storage of rain water on surface and recharging of ground water. This Manual on "Rain Water Harvesting & Conservation" is being brought out as the guidelines for optimum utilization of rain water.

I am thankful to my team of officers comprising Shri D. K. Garg, CE(D&DM), Shri N. K. Bansal, SE(D-II), Shri. D. K. Das, EE (Tech), Shri R. K. Gandhi. EE (D-VII), Shri Aakash Deep Sharma, EE(D-III), Shri Jai Prakash, AEE and Shri Suresh Sharma, Steno for the efforts put in by them in bringing out this publication in a short time.

I am also thankful to Shri Prabhakar Singh, DG, CPWD for the encouragements to bring out this version of the Manual.

(Dr. K. M. Soni)
Addl. Director General (Tech)

New Delhi.
Dated : July, 2019

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Rain Water Harvesting & Conservation, is the activity of direct collection of Rain Water. The Rain Water so collected can be stored for direct use or can be recharged into the Ground Water.

1.2 The artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding that obtained under natural conditions of replenishment. Any man made scheme or facility that adds water to an aquifer may be considered to be an artificial recharge system. Theoretically this will imply that the vertical hydraulic conductivity is high, while the horizontal hydraulic conductivity is moderate.

1.3 In Artificial recharge techniques normally address the following issues:

i) To enhance the sustainable yield in areas where over development has depleted the aquifer.

ii) To utilize the rainfall runoff, which is going to sewer or storm water drain.

iii) Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period.

iv) Surface water is inadequate to meet our demand and we have to depend on ground water.

v) Due to rapid urbanization, infiltration of rainwater into the sub soil has decreased drastically and recharge of ground water has diminished

vi) To reduce or balance salt water intrusion.

vii) To improve the vegetation cover and reduce flood hazard.

viii) To raise the water levels in wells and bore wells that are drying up. To remove bacteriological and other impurities from sewage and waste water so that water is suitable for reuse.

ix) To improve the quality of existing Ground Water through dilution.

x) To reduce power consumption.

xi) To remove suspended solids by filtration through the ground.

1.4 There are a lot of techniques available to recharge ground water reservoir. The artificial recharge techniques can be broadly categorized as follows:-

a. Direct Techniques

I) Direct surface techniques-like flooding

ii) Direct sub surface techniques- like injection wells recharge wells

iii) Combination surface – sub-surface techniques- like basin or percolation tanks with pit shaft or wells.

b. Indirect Techniques

i) Induced recharge from surface water source/Aquifer modification

Besides above, the ground water conservation structures like ground water dams, sub-surface dykes or locally termed as Bandharas, are quite prevalent to arrest sub-surface flows. Similarly in hard rock areas rock fracturing techniques including sectional blasting of boreholes with suitable techniques has been applied to inter-connect the fractures and increase recharge.

1.5 There are two main techniques of rainwater harvesting:

i) Storage of rain water on surface for future use

ii) Recharge to ground water

1.6 Rain Water Harvesting from Roofs consisting of collecting, storing and putting to use rooftop rainwater from houses or any construction is rooftop rainwater harvesting.

1.7 Rainwater harvesting can also be collecting, filtering and recharging Ground Water through percolation pits, open wells or bore wells.

1.8 The sub-surface reservoirs are very attractive and technically feasible alternatives for storing surplus monsoon run off, the sub-surface reservoirs can store substantial quantity of water. The sub-surface geological formations may be considered as 'Warehouse ' for storing water that come from sources located on the land surface. Besides suitable litho-logical conditions, other considerations for creating sub-surface storages are favorable geological structures and physiographic units, whose dimensions and shape will allow retention of substantial volume of water in porous and permeable formations. The sub-surface reservoirs, located in suitable hydro-geological situations, are environment friendly and economically viable proposition. The sub-surface storages have advantages of being free from the adverse effects like inundation of large surface area, loss of cultivable land, displacement of local population, substantial evaporation losses and sensitivity to earthquakes. No gigantic structures are needed to store water.

1.9 The storage of rainwater on surface is a traditional technique and structures used were underground tanks, ponds, check dams, weirs etc. Recharge to ground water is a new concept of rain water harvesting and the structures generally used are:

(a) Pits (b) Trenches (c) Dug Wells (d) Hand pumps (e) Recharge wells (f) Recharge shafts (g) Lateral shafts with borewells (h) Spreading techniques

All these structures with their specifications and situations where these are to be used are detailed in chapter No. 5.

1.10 Steps taken by the Central Government to promote rain water harvesting in the country are as follws:

i) Central Ground Water Board (CGWB) has prepared a conceptual document titled "Master Plan for Artificial Recharge to Ground Water – 2013" which provides information about area specific artificial recharge techniques to augment the ground water resources based on the availability of source water and capability of subsurface formations to accommodate it. The Master Plan envisages construction of about 1.11 crore artificial recharge structures in urban and rural areas at an estimated cost of Rs. 79178 crore. This comprises around 88 lakh recharge structures/ facilities utilizing rainwater directly from roof top and more than 23 lakh artificial recharge and rainwater harvesting structures for conserving surplus runoff to augment the groundwater resources. It is estimated that annually about 85,565 MCM of surplus run-off can be harnessed to augment the ground water. The Master Plan is available in public domain and has also been circulated to the State Governments for its implementation.

ii) The National Water Policy (2012) formulated by Ministry of Water Resources, RD &GR, inter-alia, advocates conservation, promotion and protection of water and highlights the need for augmenting the availability of water through rain water harvesting, direct use of rainfall and other management measures. The National Water Policy (2012) has been forwarded to all State Governments/UTs and concerned Ministries / Departments of Central Government foradoption.

iii) CGWA has been constituted under "The Environment (Protection) Act, 1986" for the purpose of regulation and control of ground water development and management in the Country. So far, CGWA has notified 162 areas in the Country for the purpose of regulation of ground water.

iv) CGWA has issued advisories to States and UTs to take measures to promote/adopt artificial recharge to ground water/rainwater harvesting. 30 States/UTs have made rainwater harvesting mandatory by enacting laws or by formulating rules & regulations or by including provisions in building bye-laws or through suitable Government Orders.

v) This Ministry has circulated a Model Bill to all the States/UTs to enable them to enact suitable ground water legislation for its regulation and development which includes provision of rain water harvesting. So far, 15 States/UTs have adopted and implemented the ground water legislation on the lines of Model bill.

vi) CGWB has taken up Aquifer Mapping and Management programme (NAQUIM) during XII Plan, under the scheme of Ground Water Management and Regulation. The Aquifer Mapping is aimed to delineate aquifer disposition and their characterization for preparation of aquifer/area specific ground water management plans, with community participation.

vii) Model Building Bye Laws, 2016 circulated by Ministry of Urban Development include the provision of Rainwater Harvesting. As per Model Building Bye Laws, water harvesting through storing of water runoff including rainwater in all new buildings on plots of 100 sq.m and above will be mandatory. Barring the States/UT of Manipur, Sikkim Mizoram and Lakshadweep, all the States have incorporated the provisions in their respective building bye laws. The plans submitted to the local bodies shall indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells. Further, all building having a minimum discharge of 10,000 litre and above per day shall incorporate waste water recycling system. The recycled water should be used for horticultural purposes.

viii) Department of Land Resources is currently implementing 8214 watershed development projects in 28 States covering an area of about 39.07 million ha. under the Watershed Development Component (WDC) of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) principally for development of rain fed portions of net cultivated area and culturable wastelands. The major activities taken up under the WDC-PMKSY, inter-alia, include ridge area treatment, drainage line afforestation, soil and moisture conservation, rain water harvesting, horticulture, and pasture development etc.

(ix) The Ministry of Rural Development in consultation and agreement with the Ministry of Water Resources, RD & GR and the Ministry of Agriculture & Farmers' Welfare has developed an actionable framework for Natural Resources Management (NRM), titled “Mission Water Conservation” to ensure gainful utilization of funds. The Framework strives to ensure synergies in Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Integrated Watershed Management Programme (IWMP) and Command Area Development & Water Management (CAD&WM), given their common objectives. Types of common works undertaken under these programmes / schemes are water conservation and management, water harvesting, soil and moisture conservation, groundwater recharge, flood protection, land development, Command Area Development & Watershed Management.

CHAPTER 2

RAIN WATER HARVESTING

2.1 Rain Water Harvesting can be defined as activity of direct collection of Rain Water and storage of Rain Water as well as other activities aimed at harvesting and conserving surface and Ground Water, prevention of loss through evaporation and seepage and other hydrological studies and engineering inventions aiming at most efficient utilization of the Rain Water towards best use for the humanity.

2.2 Glossary of Terms:

2.2.1 Aquifer (also called ground water aquifer) any underground formation of soil or rock which can yield water.

2.2.2 Artificial recharge: Any man made scheme or facility that adds water to an aquifer is artificial recharge system.

2.2.3 Bore well: Small diameter wells, which are generally deeper than open wells.

2.2.4 Dug Wells: Traditionally used large diameter wells. Defined precisely as pits excavated in the ground until the water table is reached, supported on the sides by RCC/Bricks/Stones Walls, diameters could vary from 0.6 metres onwards.

2.2.5 Ground Water: The water retained in the intergranular pores of soil or fissures of rock below the water table is called ground water.

2.2.6 Masonry: A wall or other structures made using building blocks like bricks or stone with binding materials like cement or lime.

2.2.7 Open Wells: Same as dug well. These wells were kept open in earlier days for manual withdrawal of water. Today, with electrical or diesel/petrol pumps, these can be fully covered.

2.2.8 Runoff: Runoff is the term applied to the water that flows away from a surface after falling on the surface in the form of rain.

2.2.9 Recharge: The process of surface water (from rain or reservoirs) joining the ground water aquifer.

2.2.10Water Table: The level of water within granular pores of soil or fissures of rock, below which the pores of the host are saturated.

2.3 Central PWD has been constructing and maintaining very large number of government buildings and there is enormous scope for the department to contribute towards this process of Rain Water harvesting and conservation.

2.4 The decision whether to store or recharge water depends on the rainfall pattern of a particular region. In a region where rain fall throughout the year, barring a few dry periods, in such situations a small domestic sized water tank for storing rainwater can be used. Since the period between two spells of rain is short.

In other region where total annual rain fall occurs only during three to four months of monsoon, the water collected during monsoon has to be stored throughout the year which means that huge volumes of storage container are required so it is feasible to use rain water to recharge ground water aquifers rather than for storage.

2.5 Quantity of Rain Water & General Arrangement

The quantity of Rain Water, which can be harvested, depends upon the annual rainfall, the area of the plot (catchment area) and soil characteristics. The amount of water infiltrated into the soil varies with the condition of soil surface and the moisture content of the soil at the time of rainfall. The total amount of water infiltered depends on the infiltration opportunity time, which depends mainly on the slope of the land and the field structures like contour bunds, terraces and other structures, which tend to hold the runoff water over long periods on the land surface.

Rainfall data for major cities are as given in Table No. 1 *(Source: Climatological tables of observations in India (1951 - 1980) by Indian Metrological Department)*

2.6 Artificial Recharge structures for Surface Run Off.

2.6.1 Ditch and furrow method *(Refer Drawing No. 1)*

In areas with irregular topography, shallow, flat-bottomed and closely spaced ditches or furrows provide maximum water contact area for recharge water from source stream or canal. This technique requires less soil preparation than the recharge basins and is less sensitive to silting.

2.6.2 Lateral ditch pattern *(Refer Drawing No. 1)*.

The water from stream is diverted to the feeder canal/ditch from which smaller ditches are made in right angles. The rate of flow of water from the feeder canal to these ditches is controlled by gate valves. The furrow depth is kept according to the topography and also with the aim that maximum wetted surface is available along with maintenance of uniform velocity.

The excess water is routed to the main stream through a return canal along with residual silt.

2.6.3 Percolation tanks (PT) Spreading, Basin *(Refer Drawing No. 02)*

These are the most prevalent structures in India as a measure to recharge the ground water reservoir both in alluvial as well as hard rock formations. The efficacy and feasibility of these structures is more in hard rock formations where the rocks are highly fractured and weathered. In the states of Maharashtra, Andhra Pradesh, Madhya Pradesh, Karnataka and Gujrat, the percolation tanks have been constructed in plenty in basaltic lava flows and crystalline rocks. Percolation tanks are also constructed to recharge deeper aquifers where shallow or superficial formations are highly impermeable or clayey with certain modification.

While taking decision on construction of percolation tanks following points should be kept in mind.

i) In semi arid region the storage capacity of percolation tanks should be such that the water should percolate to ground water reservoir before onset of summer because during summer season evaporation losses would be higher.

ii) The percolation tank should be provided in the catchment where submergence area is smaller and such submergence area should be in un-cultivatable land.

iii) Percolation tank should be located in highly fractured and weathered rock for speedy re-charge. In case of alluvium soil, the boundary formation (natural bunds) is ideal for locating percolation tank.

iv) The aquifer to be recharged should have sufficient thickness of permeable zone to accommodate the recharge.

v) The percolation tank should be provided in a region where sufficient number of wells and cultivatable land is there. To take advantage of recharge water.

vi) Normally 50% of total quantum of rain fall in catchment area should be considered to beside the number and size of percolation tanks.

vii) Suitable provision in the form of waste weir or spill – way to be made to allow the flow of surplus water which is in excess of maximum capacity of percolation tank in a particular day.

viii) To avoid erosion of embankment due to ripple action stone pitching to be provided up to high flood level in upstream side.

Table No. 1
Rainfall Data for Major Cities

(Source: Climatological tables of observations in India (1951 - 1980) by Indian Metrological Department)

S. No.	City	Annual rain fall (mm)(R)	S. No.	City	Annual rain fall (mm)(R)
1.	Mumbai	2146.6	38.	Solapur	750.8
2.	New Delhi(Safdarjung)	797.3	39.	Thiruvananthapuram	1827.7
3.	New Delhi(Palam)	794.0	40.	Tiruchirapalli	880.2
4.	Ahmedabad	803.4	41.	Varanasi	1025.4
5.	Bangalore	970.0	42.	Vishakhapatnam	968.8
6.	Calcutta	1641.4	43.	Portblair	3168.8
7.	Chennai	1333.8	44.	Dibrugarh	2588.7
8.	Hyderabad	812.5	45.	Tezpur	1768.3
9.	Bhopal	1146.7	46.	Chapra	1028.3
10.	Indore	1008.3	47.	Jamshedpur	1320.7
11.	Jaipur	673.9	48.	Muzaffarpur	1239.8
12.	Kanpur	832.6	49.	Bhuj	413.6
13.	Lucknow	1021.5	50.	Karnal	814.1
14.	Ludhiana	752.3	51.	Simla	1424.8
15.	Nagpur	1112.7	52.	Bidar	981.1
16.	Pune	721.7	53.	Hoshangabad	1225.9
17.	Surat	1209.4	54.	Ratlam	1033.5
18.	Agra	776.5	55.	Ujjain	934.1
19.	Allahabad	1017.7	56.	Kolhapur	1138.5
20.	Amritsar	681.2	57.	Imphal	1353.1
21.	Aurangabad	688.02	58.	Shillong	2050.5
22.	Bareli	1071.9	59.	Kohima	1856.0
23.	Chandigarh	1059.3	60.	Bhubaneshwar	1542.2
24.	Coimbatore	631.0	61.	Cuttak	1475.3

25.	Gorakhpur	1228.1	62.	Pathankot	1319.0
26.	Guwahati	1717.7	63.	Alwar	774.6
27.	Gwalior	899.0	64.	Vellure	1004.4
28.	Jabalpur	1331.6	65.	Agartala	2178.6
29.	Kochi	3228.3	66.	Aligarh	781.6
30.	Kota	761.4	67.	Dehradun	2315.4
31.	Madurai	873.3	68.	Roorkee	1156.4
32.	Meerut	901.0	69.	Darjilling	2667.1
33.	Nasik	703.0			
34.	Patna	1003.4			
35.	Rajkot	726.9			
36.	Ranchi	1431.6			
37.	Salem	1014.0			

2.7 Sample Calculation for Quantity of Rain Water which can be harvested

2.7.1 How much water can be harvested?

The total amount of water i.e. received in the form of rainfall over an area is called the rainwater endowment of that area. Out of this the amount that can be effectively harvested is called the rainwater harvesting potential.

Rain water harvesting potential	=	Rain fall (mm) x collection efficiency.
Annual rain fall of any city/place		(Say) 600 mm (Ref Table No.1)
Area of Roof Catchment		100 Sqm
Height of rainfall	=	0.6m
Vol. of rain fall over the plot	=	Area plot x height of rain fall
Rain water endowment of that area	=	100 Sqm x 0.6m = 60 cum
	=	60,000 litres (Say 'A')

Sample calculation for effectively harvested water from total rainfall

i) Considering roof catchment is having tile finish so coefficient for roof surface can be adopted as 0.85 (Ref Table No. 2)

ii) Another constant coefficient for evaporation, spillage and first flush wastage can be considered as 0.80 (for all situations).

Statistically and approximately only effectively harvested water quantity may be considered as = Rain Water endowment of that area ('A') x 0.80 x Surface efficient (to be obtained from Table No.2)

= 60,000 x 0.80 x 0.85

= 40,800 litres

This volume is about twice the annual drinking water requirement of a 5 member family. The average drinking water is required per person per day is 10 liters.

2.8 The collection efficiency accounts for the facts that all the rain water falling over an area cannot be effectively harvested because of evaporation spillage etc. Factor like run off coefficient as stated for various types of roof and land surfaces etc. as shown in Table No. 2 and the first flush wastage i.e. first spell of rain is flushed out, evaporation and spillage does not enter the system so a constant co-efficient of 0.80 may be adopted for all situations. This is done because the first spell of rain carries with it a relatively larger amount of pollutants from the air and catchment surface

Table No. 2
Runoff co-efficient of various surfaces

(Source: ASCE and WPCF 1969)

1.	**Roof Catchment**	**Co-efficient**
1.1	Tiles	0.8 - 0.9
1.2	Corrugated metal sheets	0.7 - 0.9
2.	**Ground Surface Covering**	
2.1	Untreated Ground Catchments	
2.1.1	Soil on slope less than 10%	0.0 - 0.3
2.1.2	Rocky material catchment	0.2 - 0.5
2.1.3	Business Area	
2.1.3.1	Down town	0.70 - 0.95
2.1.3.2	Neighbourhood	0.50 - 0.70
2.2	Residential Complexes in Urban Areas	
2.2.1	Single family	0.30 - 0.50
2.2.2	Multi units, detached	0.40 - 0.60
2.2.3	Multi units, attached	0.60 - 0.75
2.3	Residential Complexes	
2.3.1	In Suburban Areas	0.25 - 0.40
2.3.2	Apartments	0.50 - 0.70
2.4	Industrial	
2.4.1	Light	0.50 - 0.70
2.4.2	Heavy	0.60 - 0.90
2.5	Parks, cemeteries	0.10 - 0.25
2.6	Play grounds	0.20 - 0.35
2.7	Railroad yard	0.20 - 0.35
2.8	Unimproved Land Areas	0.10 - 0.30
2.9	Asphaltic or concrete pavement	0.70 - 0.95
2.10	Brick pavement	0.70 - 0.85

2.11	Lawns, sandy soil having slopes	
2.11.1	Flat 2%	0.05- 0.10
2.11.2	Average 2 to 7%	0.10- 0.15
2.11.3	Steep 7%	0.15- 0.20
2.12	Lawns, clayeysoil having slopes	
2.12.1	Flat 2%	0.13 to 0.17
2.12.2	Average 2 to 7%	0.18- 0.22
2.12.3	Steep 7%	0.25- 0.35
2.13	General Driveways and walls	0.15- 0.30

Whereas the use of the runoff coefficients implies there is a constant ratio of rainfall to runoff, the actual ratio will vary over the course of a storm due to condition of the area and the variability of the rainfall pattern. A common practice is to use average coefficients for various types of areas and assumed that the coefficients will be constant throughout the duration of the storm.

CHAPTER 3

ROOF TOP RAIN WATER HARVESTING

3.1 Domestic Rain Water harvesting or roof top Rain Water harvesting is the technique through which Rain Water in captured from roof catchments and stored in tanks/reservoir/Ground Water aquifers. It consists of conservation of roof top Rain Water in urban areas and utilizing it to augment Ground Water storage by artificial recharge. It requires connecting the outlet pipe from roof top to divert collected water to existing well/tube well/bore well or a specially designed well.

The details of such sample schematic arrangements under few typical type of colonies have been shown in Drawing No.03 to 08 for general guidance.

3.2 The approximate volume of water available for harvesting with respect to roof top area and annual rain fall of that area has been shown in Table No. 3 on page - or designing the Rain Water Harvesting Structures.

3.3 Roof Top Rain Water harvesting & Conserving Systems, both small and large are comprised of six basic components as described below:

i) Catchment Area/Roof: Surface upon which rain falls.

ii) Gutters and Downspouts: transport channels from catchment surface to storage.

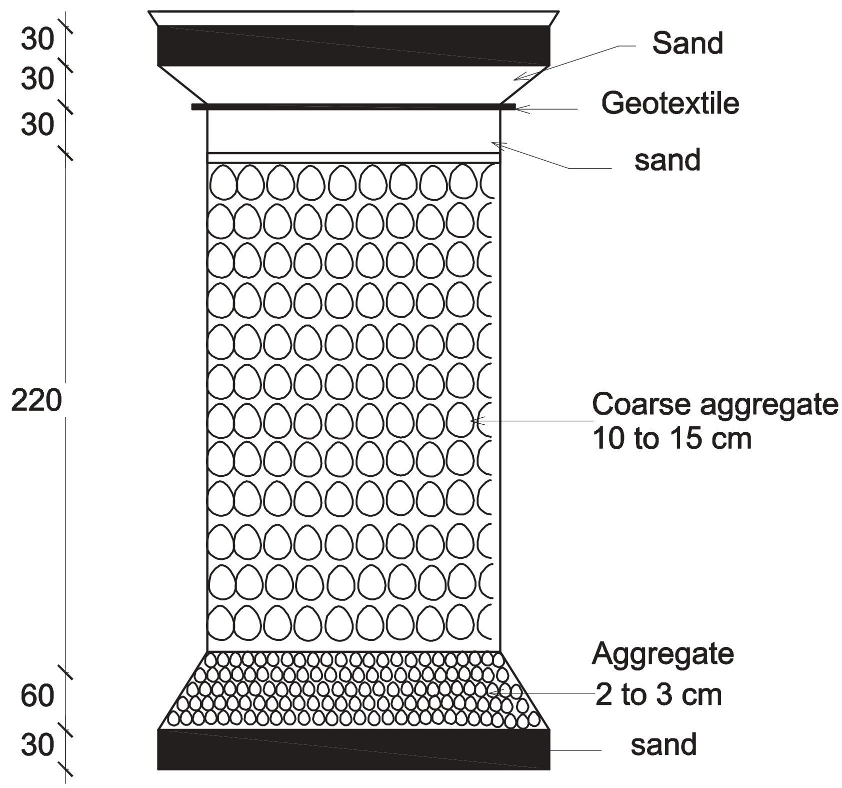
iii) Leaf Screens and Roof Washers: Systems that remove contamination and debris.

iv) Cisterns or Storage Tanks: where collected Rain Water is stored

v) Conveying: the delivery system for treated Rain Water, either by gravity or pump

vi) Water Treatment: filters and equipment and additives to settle, filter and disinfect.

3.4 The system involves collecting water that falls on roof of a house during rain storms, and conveying it to a collector to a nearby covered storage unit or cistern. Rain water yield varies with the size and texture of the catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity. This can also be improved by process of f iltration which includes processes such as mechanical straining, sedimentation, biological metabolism and electrolytic charges. Use of needled non-woven fabric in combination of geo-grid, filters the rain water and accelerates water recharge rate. The water harvesting using geo-synthetics is cost effective way for ground water recharge. It also helps in resolving the water logging in heavy rains. Sectional view of the pit along with the details of various filling layers in the pit is shown in the figure below. Non-woven geotextile grid needs to be replaced during maintenance as and when required to improve the working efficiency of the rain water harvesting system.



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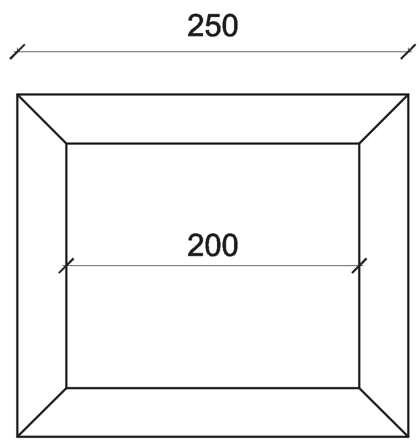


PLAN

Table No. 3
Avalability of rain water through roof toprain water harvesting

(Source: CGWB Guide)

Rain Fall (MM)	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000
Rooftop Area (Sqm)	Harvested Water from Roof Top (cum)												
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48
40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64
50	4	8	12	16	20	24	32	40	48	56	64	72	80
60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96
70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112
80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	115.2	128
90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144
100	8	16	24	32	40	48	64	80	96	112	128	144	160
150	12	24	36	48	60	72	96	120	144	168	192	216	240
200	16	32	48	64	80	96	128	160	192	224	256	288	320
250	20	40	60	80	100	120	160	200	240	280	320	360	400
300	24	48	72	96	120	144	192	240	288	336	384	432	480
400	32	64	96	128	160	192	256	320	384	448	512	576	640
500	40	80	120	160	200	240	320	400	480	560	640	720	800
1000	80	160	240	320	400	480	640	800	960	1120	1280	1440	1600
2000	160	320	480	640	800	960	1280	1600	1920	2240	2560	2880	3200
3000	240	480	720	960	1200	1440	1920	2400	2880	3360	3840	4320	4800

3.5 The broad idea about the particular diametre of pipe which will be required to cater the certain roof surface area for given average rate of rain fall in millimeter per hour is shown in Table No. 4

Table No. 4
Sizing of rain water pipes for roof drainage

(Source: SP -35)

S.No.	Diameter of pipe (mm)	Average rate of Rain Fall (mm per hour)					
		50	75	100	125	150	200
		Roof Area (Sqm)					
(i)	50	13.4	8.9	6.6	5.3	4.4	3.3
(ii)	65	24.1	16.0	12.0	9.6	8.0	6.0
(iii)	75	40.8	27.0	20.4	16.3	13.6	10.2
(iv)	100	85.4	57.0	42.7	34.2	28.5	21.3
(v)	125			80.5	64.3	53.5	40.0
(vi)	150					83.6	62.7

This Table will help in determining the number of pipes of particular diameter is required for given roof surface area and average of rate of rain fall in millimeter per hour for that area.

3.6 The graph No. 1 gives fair idea about amount of peak precipitation may likely to happen (shown in Y –axis) for different duration of rain falls shown in curved lines with respect to recurrence intervals shown in the years (along X-axis). This will give an idea about peak rain fall intensity for a particular station for which settlement time is to the designed for 15 minutes duration of peak rain falls.

3.7 Data Requirements for design of Roof Top Rain water Harvesting System.

The summary data sheet showing the data requirements for design of a successful roof top rainwater harvesting system is shown in Table 5

Table No. 5
Summary data sheet for designing rainwater harvesting system

1. Type of buildings:	
a. Residential	
b. Commercial	
c. Industrial	
d. Park	
e. Open area	
2. Layout plan of the building:	
a. Roof top area	
b. Paved area	
c. Open area	
3. Water availability	
a. Rainfall(Data on daily basis for two years)(if available)	
b. Rain fall intensity	
c. Number of rainy days	
d. Height of roof	
4. Water withdrawal:	
a. Number of tube wells	
b. Discharge	
c. Number of hrs operated per day	
5. Quality of source water:	
6. Number and locations:	
a. Tube wells	
b. Bore wells	
c. Hand pumps	

7. Type of roof:	
a. Flat roof	
b. Sloping roof	
8. Rainwater disposal system: a. Drain pipes	
I) Up to ground	
ii) Above ground	
b. If sloping roof	
i) Gutters	
ii) Size of gutter	
9. Type of drain pipes	
a. GI	
b. Cement	
c. PVC	
d. Others	
10. Hydrogeological settings	
a. Depth to water level	
b. Geological formation water bearing strata and water bearing formation	
c. Type of soil	
d. Depth of clay bands/clay	
e. Depth of tube wells	
f. Present discharge of tube wells	
g. Assembly chart of tube wells	
h. Hydraulic conductivity	

i. Specific yield of aquifer	
j. Storage capacity of aquifer	
k. Ground water flow pattern	
l. Thickness of soil cover	
m. Infiltration rate :	
i) Soil	
ii) Aquifer	
11. Any other information such as:	
a. Problems due to submergence area area and location	
b. Rainwater coming from adjoining area	
b. Lack of storm water drains	
c. Decline/failure of tube wells	
d. Tube wells started giving saline or bad quality of water	

CHAPTER 4

DESIGN OF STORAGE/SETTLEMENT TANKS

4.1 Design for Storage Tanks

The quantity of water stored in a water harvesting system depends on size of the catchment area and the size of the storage tanks. The storage tanks have to be designed according to the water requirements, rain fall and catchment availability. The rain water is to be stored for drinking purpose in a situation shown in para 2.4.

4.1.1 The decision to decide the size of storage tank must be governed by the infiltration capacity of the soil instead of runoff yield obtainable from the catchment. The size of storage tanks must not be so large that there is considerable evaporation loss. If infiltration capacity of soil is poor

then preferably small size storage tanks should be installed.

4.1.2 The depth of water impounded in the storage tank must not exceed 6 m with a minimum depth of 3 to 4.5 m. This impounded depth of water provides the head required for water to infilter through the soil.

(Source: Manual on Artificial Recharge of Ground Water, CGWB, Sep 2007)

4.1.4 Determination of soil absorption capacity can be done as per Percolation Test as described in Appendix A of IS: 2470 (Part2) 1985.

4.2 Basic Data

i) Average annual rainfall

ii) Size of catchment

iii) Drinking water requirements

Suppose the system has to be designed for meeting drinking water requirement of a 5 member family living in a building with a roof top area of 100 Sqm. Avg. annual rain fall is 600 mm. Daily drinking & cooking water requirement per person is 10 litres.

We shall first calculate the maximum amount of rain fall that can be harvested from roof top.

Area of Roof top = 100 Sqm

Runoff co-efficient for tiles surface (typical case)	=	0.85 (Ref Table No. 2)
Co-efficient for evaporation, spillage and first	=	0.80 (Ref Para 2.8) flush etc.
Annual water harvesting potential from 100 sqm roof top	=	(Area of roof top) x (Annual rain falls in metre) x (Run of coefficient to be obtained from Table 2) x (Constant co-efficient refer Para 2.8)
	=	100 x .60 x .85x0.80 = 40.8 cum = 40,800 ltr

The tank capacity has to be designed for dry period i.e. the period between two consecutive rainy seasons. With monsoon extending over 4 months the dry season of 245 days has been considered.

Drinking water requirement for family for dry season = 245x5x10 =12,250 litres.

As a safety factor, the tank should be built 20% larger than required i.e. 14700 litres = (1.2 x 12250)

This tank can meet the basic drinking & cooking water requirement of a 5 member family for the dry period.

4.2.1 Design parameters for settlement tank

Settlement tanks are used to remove silt and other floating impurities from rain water. Settlement tank is like an ordinary container having provision for in flow, out flow and over flow. Settlement tank can have an unpaved bottom surface to allow standing water to percolate into the soil. A part from removing silt from water the desilting chamber acts like a buffer in the system.

For designing the optimum capacity of the tank following aspects have to be considered:

i) Size of catchment

ii) Intensity of rainfall

iii) Rate of recharge

Since the desilting tank also acts as buffer tank, it is designed such that it can retain a certain amount of rainfall, since the rate of recharge may not be comparable with the rate of runoff. The capacity of tank should be enough to retain the run off occurring from conditions of peak rain fall intensity. In Delhi peak hourly rain fall is 90mm. The rate of recharge in comparison to run off is a critical factor However, since accurate recharge rates are not available without the rates have to be assumed.

The capacity of recharge tank is designed to retain runoff for at least 15 minutes of rainfall of the peakintensity (for Delhi 22.5 mm/per 15 minutes say 25 mm per 15 minutes).

Suppose the following data is available:

Surface Area of roof top catchment (A)	=	100 Sqm.
Peak rainfall in 15 min (r)	=	25 mm
Runoff co-efficient (c)	=	0.85

Then capacity of tank = A x r x C = 100x0.025x0.85 = 2.125 cum = 2,125 litres.

To obtain indicative peak rain fall for various stations the basic rain fall data for that station may be collected from Indian Metrological Office and refer para 3.5 and Graph No. 1 (from which peak rain fall for different duration of rain fall can be obtained for given recurrence interval in years and this recurrence interval can be related to the expected life of settlement tank structure.

4.3 Options for settlement tank

Any container with adequate capacity of storage can be used as a settlement tank. Generally masonry or concrete underground tanks are preferred. Since they do not occupy any surface area. For over ground tanks pre-fabricated PVC or ferro cement tanks can be used and prefabricated tank are easier to install so it should be preferred.

CHAPTER 5

RECHARGE STRUCTURE AND ITS DESIGN

5.1 Recharge structures

The basic purpose of artificial recharge of Ground Water is to restore supplies from aquifers depleted due to excessive Ground Water development and usage.

Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and type of recharge structures. In particular, the features parameters and data to be considered are: geological boundaries, hydrological boundaries, inflow and outflow of water, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of aquifer, tectonic boundaries. "the aquifer best suited for artificial recharge are those aquifers which absorb large quantity of water and do not release the same to quickly.

Wherever CPWD has road infrastructure and drainage system with the buildings like a campus, feasibility of providing road runoff rain water harvesting will be worked out along with rooftop rain water system. The design of rain water harvesting system will be similar to other rain water system. The rain water from the drains will be diverted to a suitable place and discharged to ground aquifer after sedimentation, and filtration arrangement.

In case rooftop runoff is connected to road runoff, overall rain water harvesting system will be designed and constructed to draw maximum advantage of combined system and easy maintainability.

5.2 Factors affecting selection of recharge structure:

There are various factors which affect the choice of recharge structure. Some of them are:

I) Pattern of rainfall in the area

ii) Topography of the area and terrain profile

iii) Land use and vegetation

v) Type of soil and soil depth

v) Hydrological and hydrogeological conditions of the area

vi) Amount of surface runoff available for ground water recharge

vii) Environmental Impact Assessment (EIA) of the proposed groundwater recharge technique

viii) Socio-economic conditions of the habitants in the area

ix) Availability of infrastructure facilities

5.3 Artificial groundwater recharge techniques

Direct methods

i) Surface (spreading) techniques

   a) Flooding

   b) Ditch and furrows

   c) Recharge basins

   d) Stream modification/augementation

ii) Runoff conservation structures

   a) Contour bunds and contour trenches

   b) Gully plugs nallah bunds, check dams

   c) Percolation ponds

   d) Bench terracing

iii) Sub-surface techniques

   a) Recharge wells (or injection wells)

   b) Gravity head recharge wells

   c) Recharge pits and shafts

Indirect methods

I) Induced recharge from surface water

ii) Modification of aquifer

iii) Bore-blasting

iv) Hydro-fracturing

v) Combination methods

  a. Sub-surface dykes (Bandharas)

  b. Fracture sealing cementation technique (to arrest sub-surface flows)

5.4 The various type of recharge structures are:

i) Recharge Through Abandoned Dug Well

ii) Recharge Through Hand Pump

iii) Recharge pit

iv) Recharge Through Trench

v) Gravity Head Recharge Tube Well

vi) Recharge Shaft

5.5 Design Guidelines:

In general the recharge structures are designed with total volume as twice the peak discharge as detailed below:

5.5.1 Abandoned well *(Refer Drawing No. 9 & 10)*

i) A dry/unused dug well can be used as a recharge structure

ii) The recharge water is guided through a pipe to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.

iii) Before using the dug well as recharge structure, its bottom should be cleaned and all the fine deposits should be removed

iv) Recharge water should be silt free as far as possible.

v) It should be cleaned annually preferably.

vi) It is suitable for large building having the roof area more than 1000 Sqm

vii) The run off of first rain should not be allowed to percolate to the rainwater harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

5.5.2 Recharge pit *(Refer Drawing No. 12)*

i) Recharge pits are constructed for recharging the shallow aquifer.

ii) These are constructed generally 1 to 2 m wide and 2 to 3 m deep

iii) After excavation, the pits are refilled with pebbles and boulders

iv) Water to be recharged should be silt free as far as possible.

v) Cleaning of the pit should be done annually preferably.

vi) It is suitable for small buildings having the roof top area upto 100 Sqm

vii) Recharge pit may be of any shape i.e. circular, square or rectangular.

viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

ix) If the pit is of trapezoidal shape, the side slopes should be steep enough to avoid silt deposition.

5.5.3 Recharge trench *(Refer Drawing No. 13 & 14)*

i) It is constructed when permeable strata of adequate thickness are available at shallow depth.

ii) It is a trench of shallow depth filled with pebbles and boulders.

iii) These are constructed across the land slope.

iv) The trench may be 0.5 to 1 m wide 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of land and roof top area.

v) It is suitable for the buildings having the roof area of 200 to 300 sq.m.

vi) Cleaning of trench should be done periodically.

5.5.4 Gravity head recharge well *(Refer Drawing No. 15 to 19)*

i) Bore wells/tube wells can be used as recharge structure.

ii) This technique is suitable where:

a. Land availability is limited

b. When aquifer is deep and over laid by impermeable strata (clay)

iii) The roof top Rain Water is channelized to the well and recharges under gravity flow condition.

iv) Recharge water should be silt free as far as possible.

v) The well can also be used for pumping.

vi) Most suitable for the areas where Ground Water levels are deep.

vii) The number of recharging structures can be determined in limited area around the buildings depending upon roof top area and aquifer characteristics.

viii) The run off of 1st rain should not be allowed to go percolate to the rain water harvesting structure and allowed it to go to the drain by making suitable by-pass arrangement in water carrying pipe systems.

5.5.5 Recharge shaft *(Refer Drawing No. 20 to 22)*

i) A recharge shaft is dug manually or drilled by the reverse/direct rotary method.

ii) Diameter of recharge shaft varies from 0.5 to 3 m depending upon the availability of water to be recharged.

iii) It is constructed where the shallow aquifer is located below clayey surface.

iv) Recharge shaft is back filled with boulders, gravels and coarse sand.

v) It should end in more permeable strata (sand).

vi) Depth of recharge shaft varies from 10 - 15 m below ground level.

vii) Recharge shaft should be constructed 10 to 15 m away from buildings for the safety of building.

viii) It should be cleaned annually preferably by scraping the top layer of sand and refilling it accordingly.

5.6 Maintenance of recharge structure

Roof Top Rain Water Harvesting for Ground Water recharge involves injection of rain water in to the aquifer through recharge trench cum tube wells under gravity flow. The surface water although treated through the filter bed may cause clogging after comparatively short periods of injection. In this case through the precaution is taken, there is a probability of silt being injected into the recharge wells and may cause clogging. Short periods of pumping quickly remove the clogging particles and improve the recharge capacity. Annual redevelopment of recharge wells by air compressor is recommended for improving the recharge capacity of trench cum recharge wells. Moreover silt deposited on sand bed also reduces the recharge rate. This also needs periodic removal of the finer material by scraping.

The type of Recharge structures to be considered for different areas (Alluvial areas or Hard Rock areas) in Delhi for various roofs are shown in Table No.5. The whole complex/colony can be suitably divided in various clusters and one of the above systems appropriate to roof size and underground characteristics may be selected for use/execution.

5.7 Modular Rain Water Harvesting System:

Modular Tank System is a subsurface water infiltration storage tank for storm water control and management system, and thus, it is also known as the Modular Rainwater Storage / Harvesting System, and Sub-soil Drainage. It is efficient, cost effective and ecologically sustainable. The main function of Modular Tank is to allow on-site natural water infiltration and this prevent surface run-off. This Underground Tank System is best applied for flat ground area for rainwater harvesting and storm water management.

This system can be constructed to hold any volume of water required. These systems are built out of modular plastic cubes. They are arranged to the appropriate size then wrapped in a liner and covered with soil and GI Sheets. This allows the storm water to be managed underground with zero-footprint that easily integrates into landscaping.

Modular cisterns are much more versatile than traditional rain tanks. This technology allows us to create load-bearing void space for underground water storage. Modules (boxes) are manufactured recycled plastics. These modules are 95 percent void space and are strong enough for vehicle traffic and parking.

Runoff water from open surface as well as from rooftops would be channelized to filtration unit. Filtration unit should consist of the following units in chronological order:

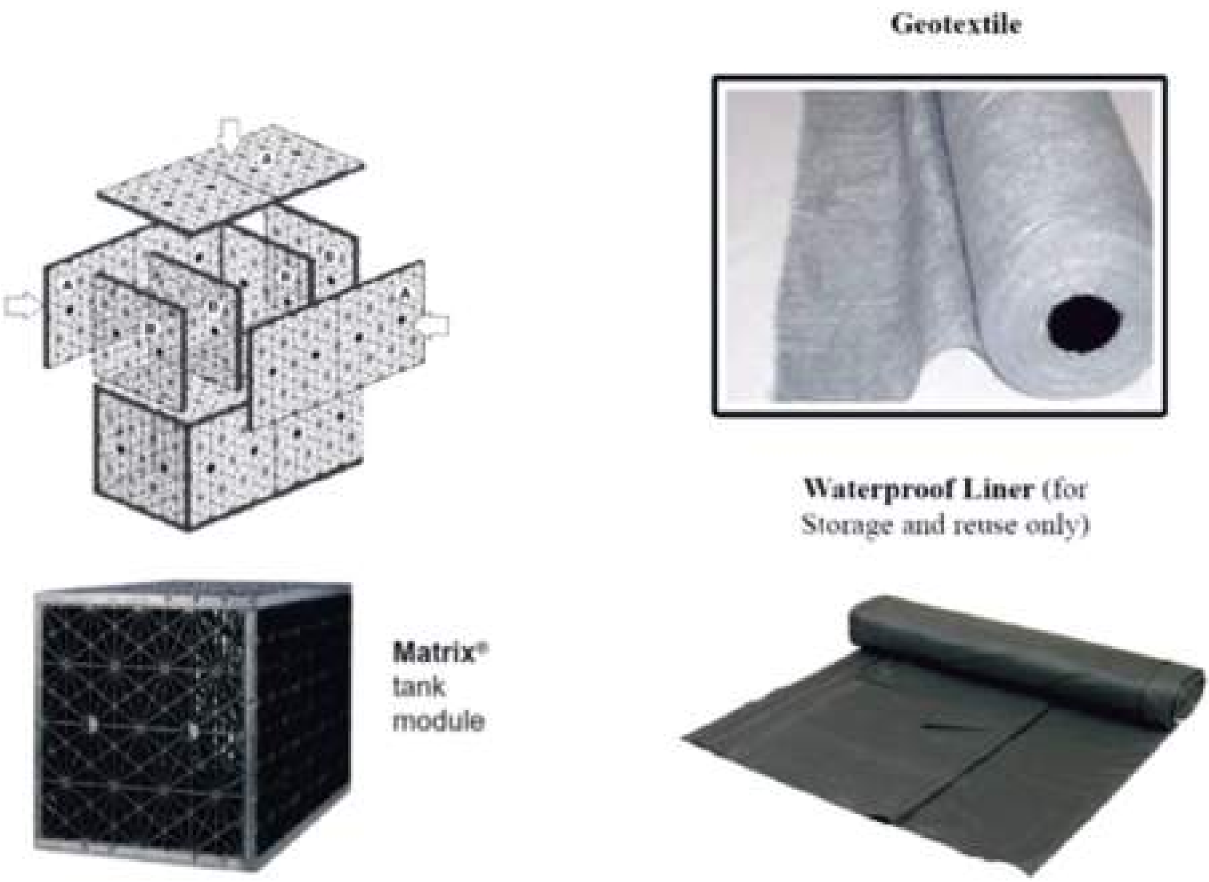
i) Sedimentation tank

ii) Filtration through micro-filter of FRP tank or similar arrangement

iii) Sand filter with geotextile layer at the top

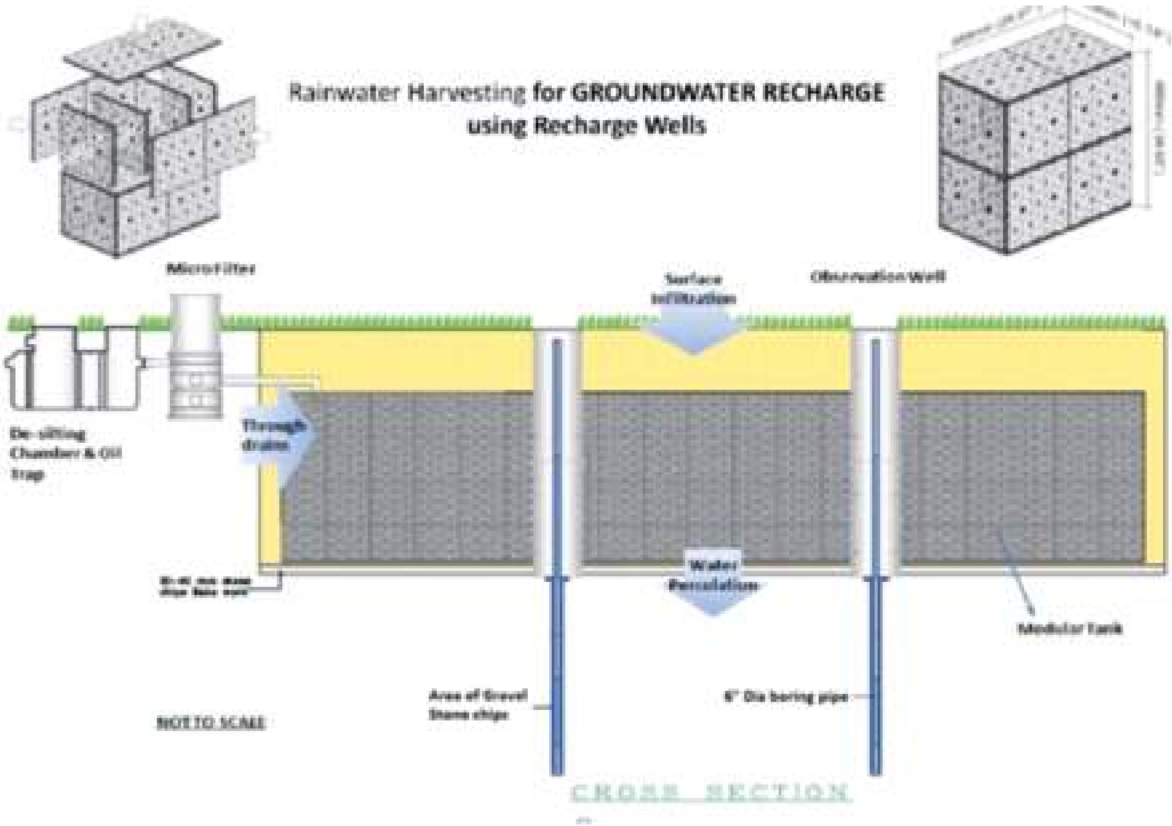
Water then would be taken to the modular Modular Rainwater Storage or similar arrangement as per site feasibility.

FRP (or similar materials) Tank with micro-filter (Geotextile)



Materials used In Modular Tank

Installation Process Overview



Flexible Applications of Modular Technology

Step – 1

De-silting Chamber/Oil Filter

- Designed for any flow situations
- Pre-manufactured, short time of installation
- Designed for **easy and low cost maintenance**

Step – 2

Patented Micro-Filter

Easy Maintenance

- Removes particles up **to 180microns** in size
- Suitable for flow situations of 72 cum/hr
- Pre-manufactured, short time of installation
- **Extremely easy to maintain – at little or no cost**

Dual step External Filtration For Easy and Inexpensive maintenance, Clog-free performance

Time for cleaning: 1 to 3 days by 2 or more workers
Maintenance Cost: INR 30,000 to 1,45,000 or more every year

Time for cleaning: 2-3 hours by 1 person
Maintenance Cost: INR 0 to 5,000 per year

Picture: Conventional maintenance vs Modular System maintenance
Clogging Issue Addressed- using Modular Technology

Comparison Modular RWH vs. Conventional RWH System from a case study during 2014

S. No.	Criteria	Modular RWH	Conventional (Concrete Tank)
1	Initial Cost of tank	INR 41,84,654	INR 64,80,000
2	Cost of filtration	External filtration unit:- INR 2,00,000	Cost of de-silting chamber:- INR 2,80,000
3	Total initial cost	INR **43,84,654**	INR **67,60,000**
4	Construction Time	12 days after recharge well	3 months
5	Maintenance cost	INR **7,000** per year	INR **1,50,000** per year
6	Maintenance Time	30 - 45 minutes	2-3 days
7	Size of tank	31.51m * 4.08m * 2.17m	30m * 4m * 6m
8	Top Surface	Infiltration from top surface	No infiltration from top

5.8 Shortcomings of Conventional Rain Water Harvesting System

i) Accumulation of poisonous gases

ii) Accident prone due to hollow structure

iii) De-silting chamber does not perform the function properly

iv) Cleaning the whole structure is tedious and expensive

v) Requires maintenance every year after three year of commissioning

vi) Alteration is very challenging

vii) Not possible to relocate

viii) Because of no movement water quality reduces

ix) Unskilled manpower is used and that reduces the quality of work

Advantages:

i) High compressive strength allows use under trafficable areas

ii) Interlocks vertically and horizontally for maximum stability

iii) Less costly than concrete and metal storage systems

iv) Time saving in installation

v) Low storage and transportation cost

vi) Caters for all volume requirements

vii) Easy assembly of panels and insallation of units

viii) Less maintenance cost than civil pit

ix) No surface water storage hazards

Challenges:

i) Requires specified excavation and burial preparation to ensure longevity of product

ii) Internal cleaning is not possible so the inlet filtration component of the rainwater collection system is extremely vital.

5.9 General Recommendations for Rain Water Harvesting

1. Guidelines for action plan for artificial recharge project:

   i) Collect basic data on topography, rainfall pattern of that area, hydro- geology aquifer situation, land-source water availability. Identify the method which is most suitable.

TABLE NO. 5

(Source: Central Ground Water Board)

Roof area (sq.m)	**Total rainfall volume considering Delhi**	**Volume available for recharge (80%) (cu.m)**	**Type of Structure recommended for recharge**	
			Alluvial area	Hard Rock area
50	30	24	Recharge pit	Recharge pit
100	60	48	do	-do-
150	90	72	do	-do-
200	120	96	Trench	Trench/Hand pump
300	180	144	do	-do-
400	240	192	Gravity head recharge well	Gravity head recharge well
500	300	240	do	-do-
600	360	288	do	-do-
800	480	384	do	-do-
1000	600	480	do	-do-
1500	900	720	do	Recharge Shaft/Dug Well
2000	1200	960	do	-do-
2500	1500	1200	Recharge Shaft/Dug Well	-do-
3000	1800	1440	do	-do-
4000	2400	1920	do	-do-
5000	3000	2400	do	-do-

ii) With reference to the local conditions of the area, further identify the most appropriate techniques of artificial recharge suitable at various sites/ locations on the basis of total available volume of rainwater which can be harvested and the location of available aquifer whether it is at shallow depths i.e. 6 to 8 meters from ground level or at sufficient depths i.e.more than 8 meters from ground level.

iii) Determine the number of each type of artificial recharge structure needed to achieve the quantitative targets. The recharge structure should be designed with volume of water it may store for equivalent of 24hours rainfall and surface area of run-off for which the recharge structure has been considered, without giving any allowance for percolation during this period of 24 hours.

iv) For individual structure at different locations, finalize the design specifications from the details given in case studies. If required, the necessary advice from local Geological Department or Central Ground Water Board may be obtained.

v) Finalize the design of the conveyance system required to bring the source water to the recharge structure site and the treatment required in the form of settlement tanks.

vi) Plan the required monitoring system to evaluate the efficiency of recharge scheme and ensure regular maintenance of recharge structures before onset of monsoon every year.

2) In a given plot attempt should be made to keep the maximum plot area as katcha area which allows rain water for percolation to ground water.

3) The rain water from season's first rain should normally not be used for percolation to recharge structure because it contains pollutants from the air and catchment surface. For such water suitable arrangement for by-pass in pipe system should be introduced.

4) A suitable provision should be made if possible to allow rain water to percolate to ground water after passing it through settlement tank because such rain water contains silt which is deposited on sand bed and reduces the percolation rates.

5) The recharge structure should be made on a plot at the places of lower levels / elevations so that rain water may flow towards it under normal gravitation flow.

6) On a vast and sloppy land patch, the contour bunds preferably of mud with height varying from 15 cm to 30 cm should be made to store run off temporarily over the katcha land area, thus allowing more time for percolation of water to the ground water and arresting the flow of run off to

the drains / sewers.

7. For recharge of runoff from r oads suitable arrangements in the foot path by introducing some katcha area should be made.

8. In large residential and office complexes the drive ways, pucca path and areas should had some katcha area which may facilitate rain water to percolate to ground water.

9. Ideal conditions for rain water harvesting and artificial recharge to ground water Artificial recharge techniques are adopted where:

    I) Adequate space for surface storage is not available especially in urban areas.

    ii) Water level is deep enough (more than 8 mtr) and adequate sub-surface storage is available.

    iii) Permeable strata are available at shallow/moderate depthsupto 10 to 15 mtr.

    iv) Where adequate quality of surface water is available for recharge to ground water.

    v) Ground water quality is bad and our aim is to improve it.

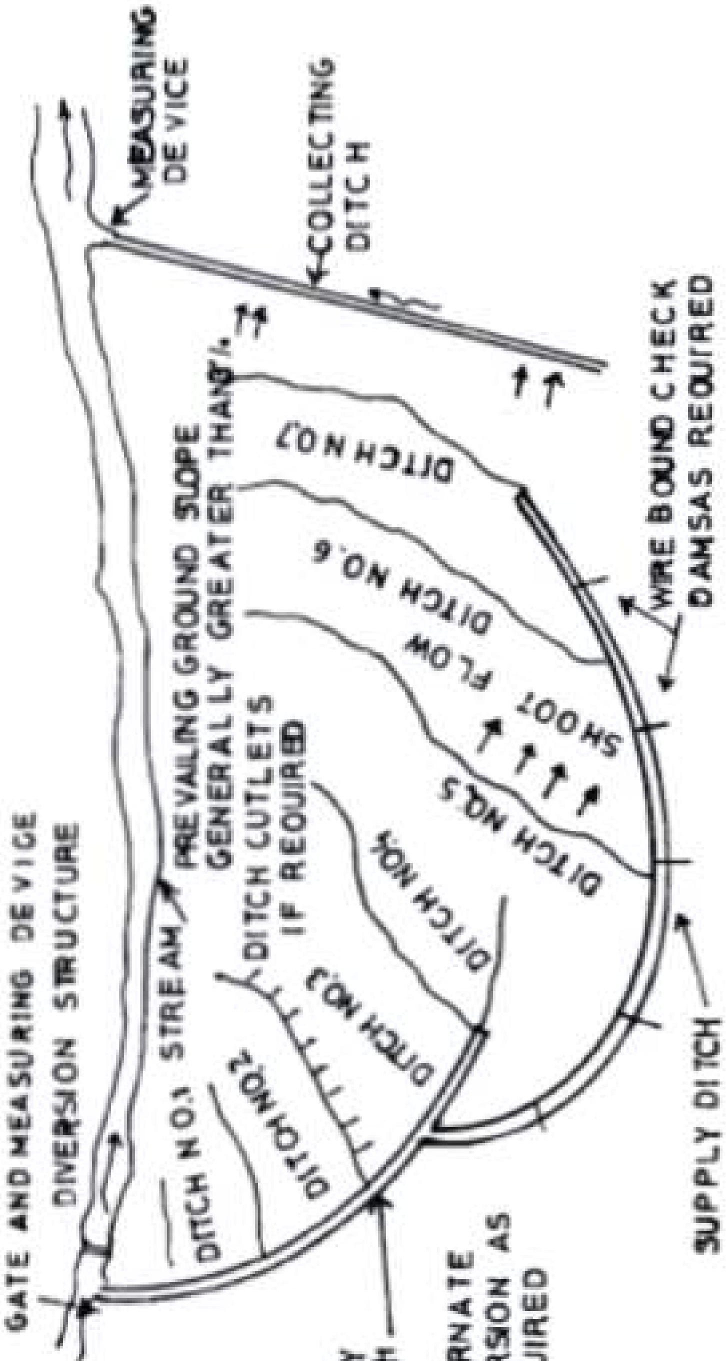
    vi) Where there is possibility of intrusion of saline water especially in coastal area.

    vii) Where the evaporation rate is very high from surface water bodies.

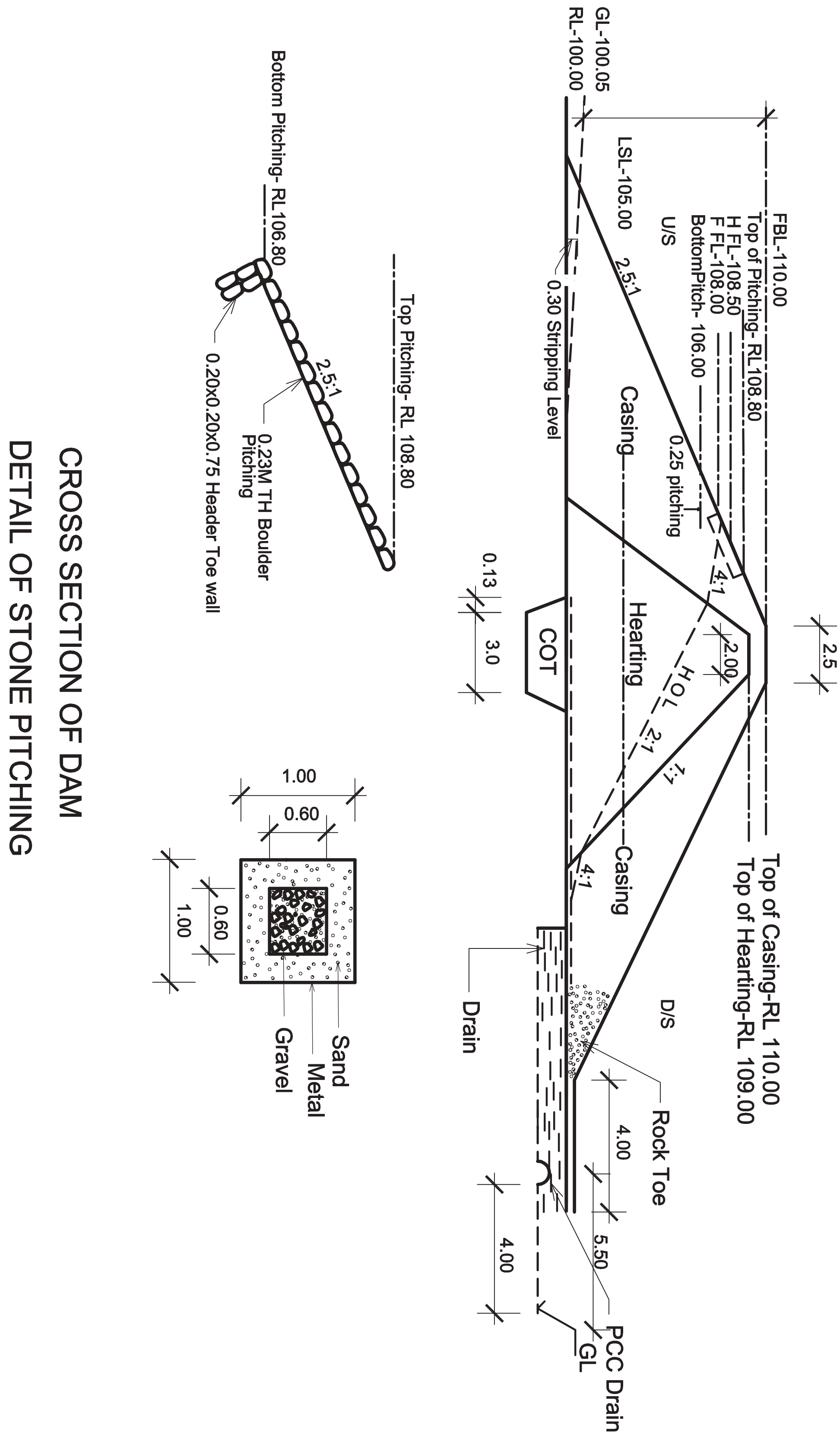
10. The decision whether to store or recharge rain water depends on the rain fall pattern of a particular region.

    i) If the rain fall period between two spells of the rain is short i.e. two to four months, in such situation a small domestic size water tank for storing rain water for drinking and cooking purpose can be used.

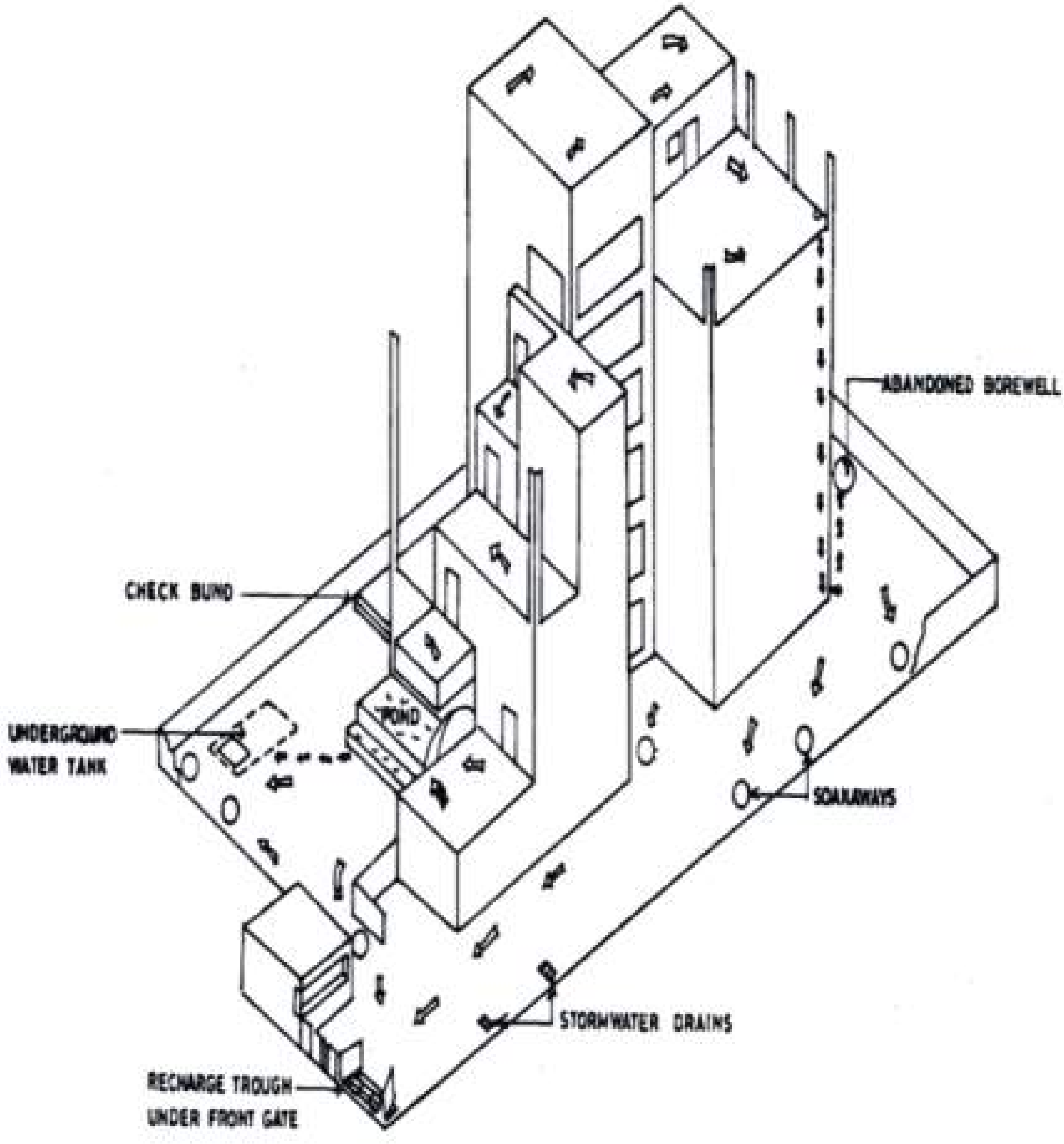
    ii) In other regions where total annual rain fall occurs only during 3 to 4 months of monsoon and the period between two such spells is very large i.e. 7 to 8 months, so it is feasible to use rain water to percolate to the ground water aquifers rather than for storage which means that huge volumes of storage container are required.



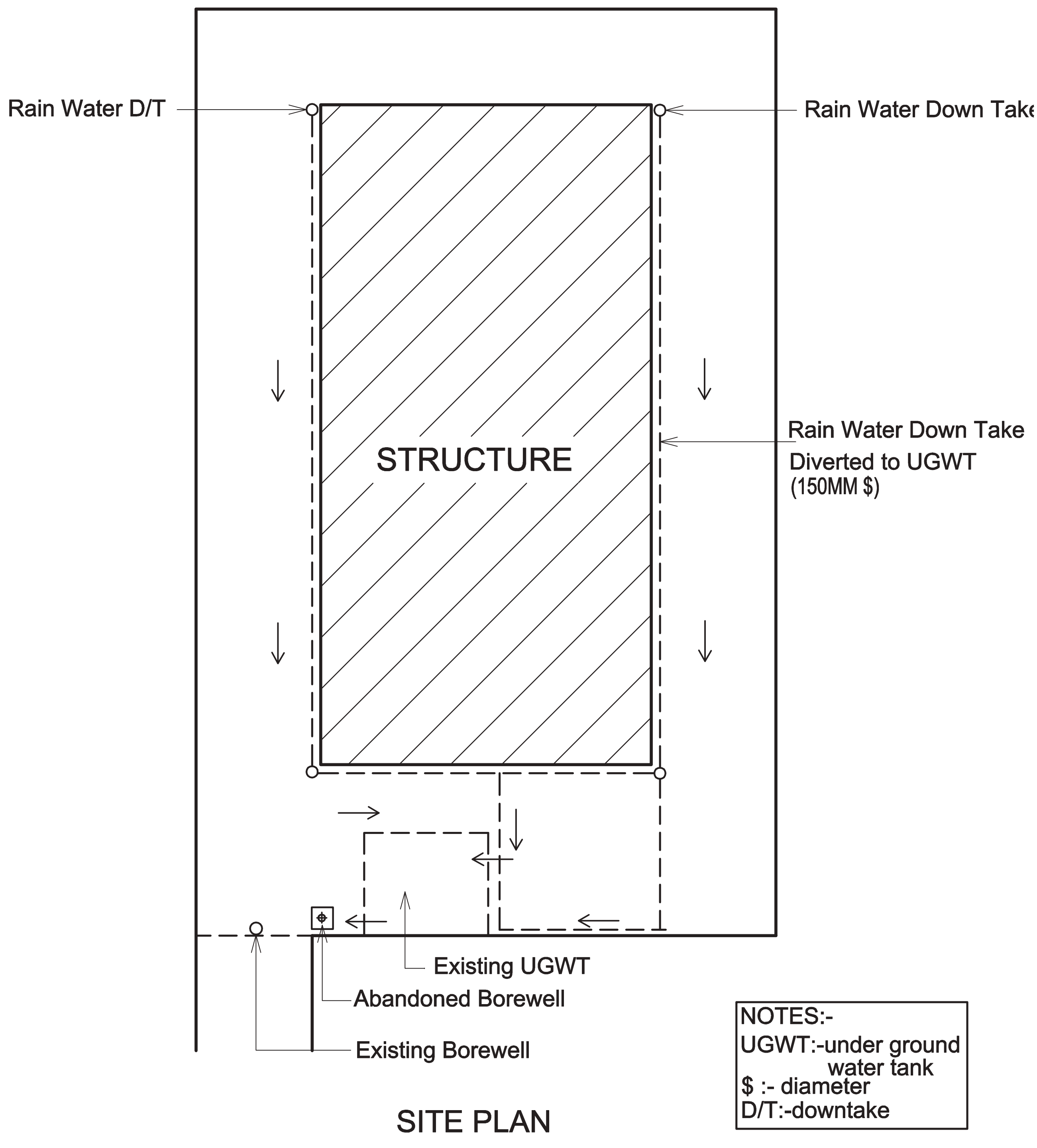
Drg. No. 1 Ditch and furrow method



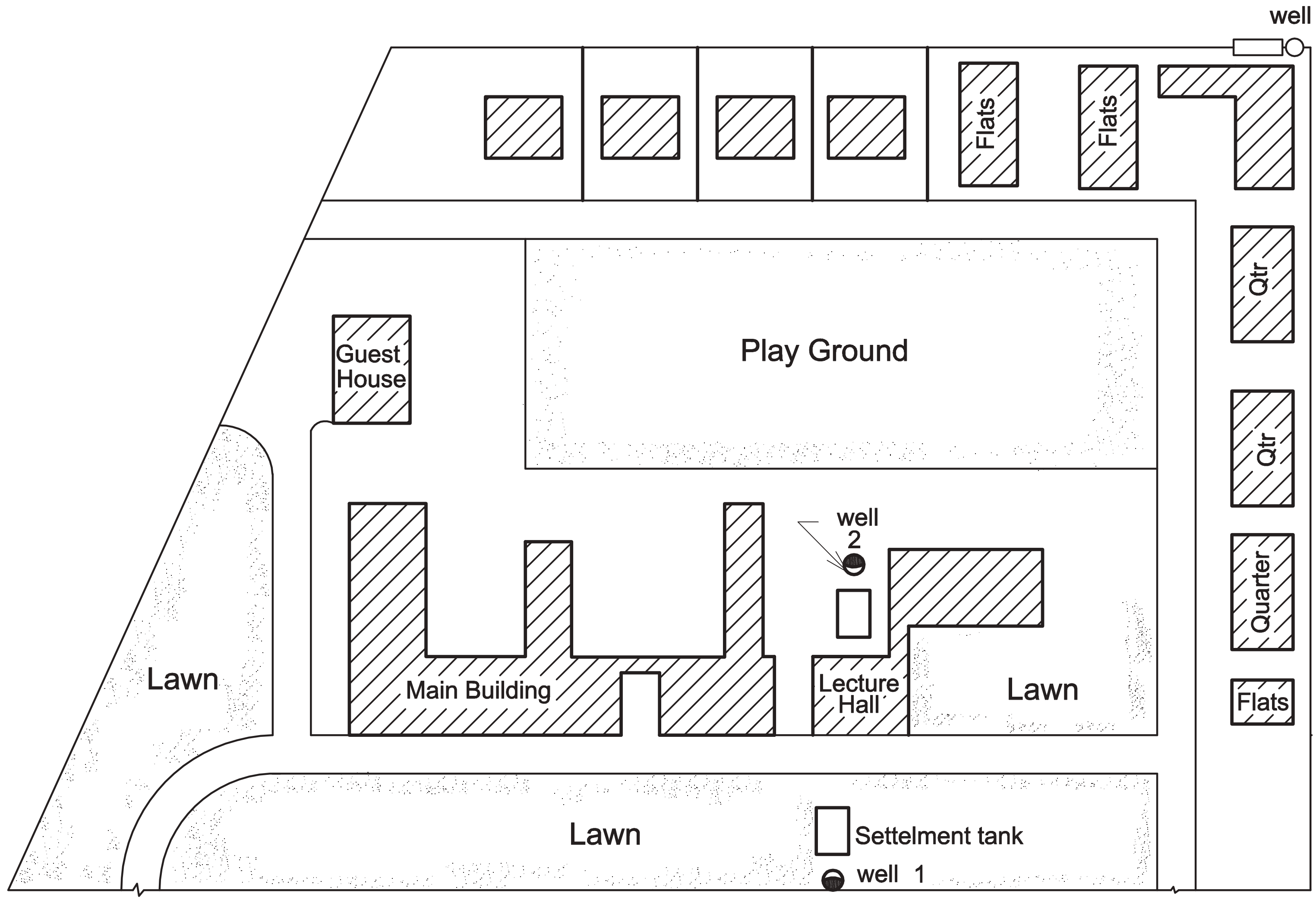
Drg. No. 2 Percolation Tank



Drg. No. 3 Water Harvesting System in a building

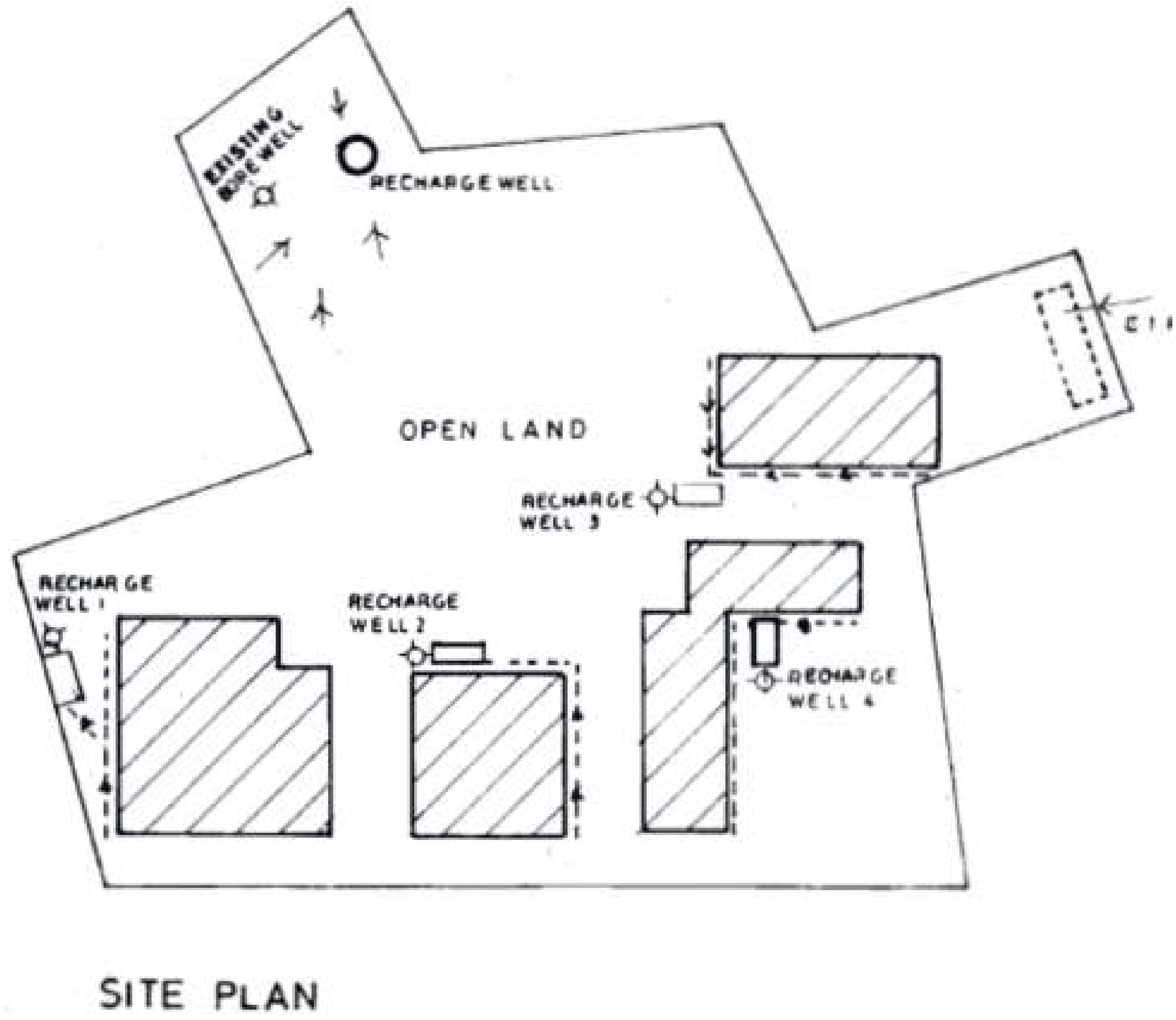


Drg. No. 4 Scheme for water harvesting

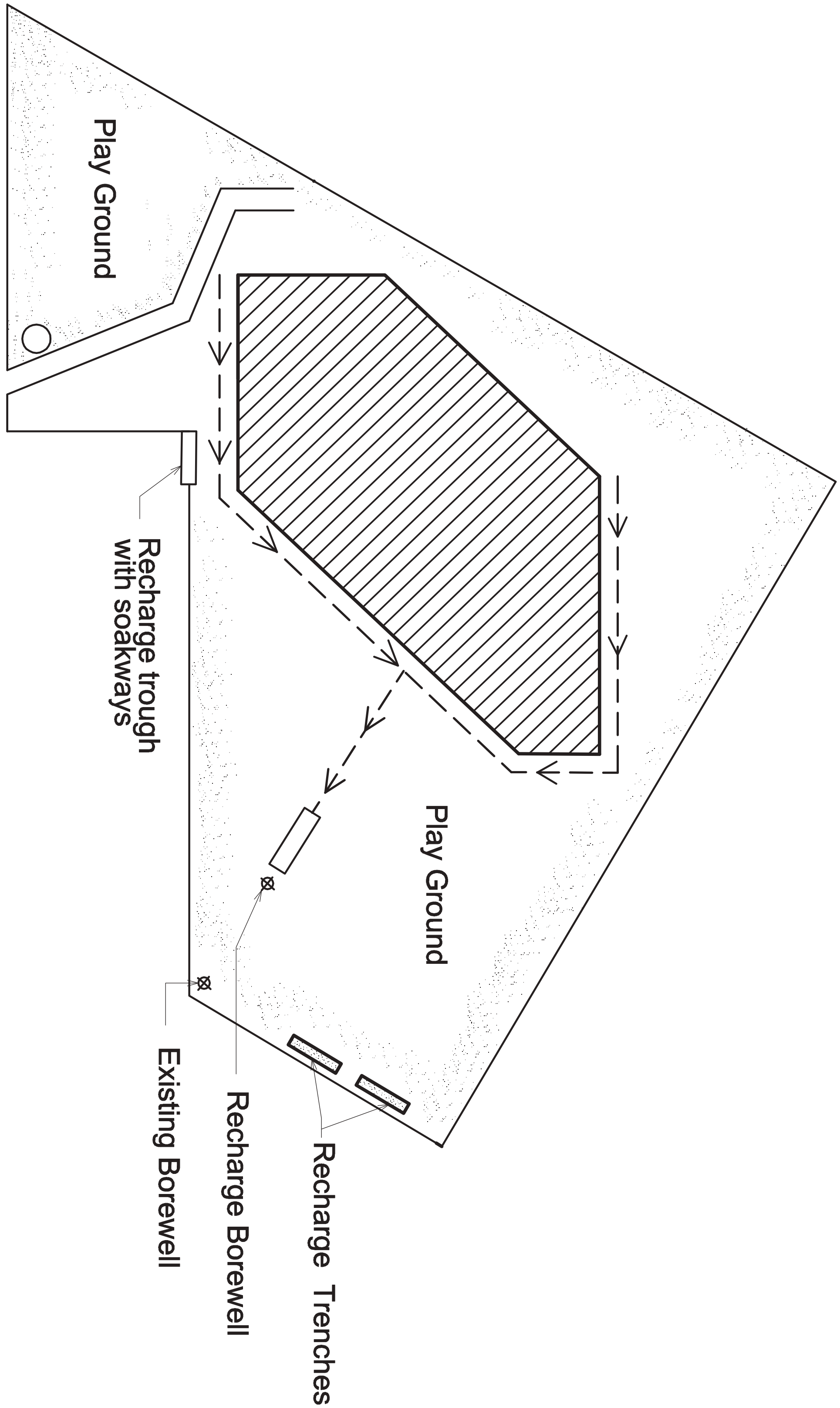


SITE PLAN

Drg. No. 5 Details of recharge pit

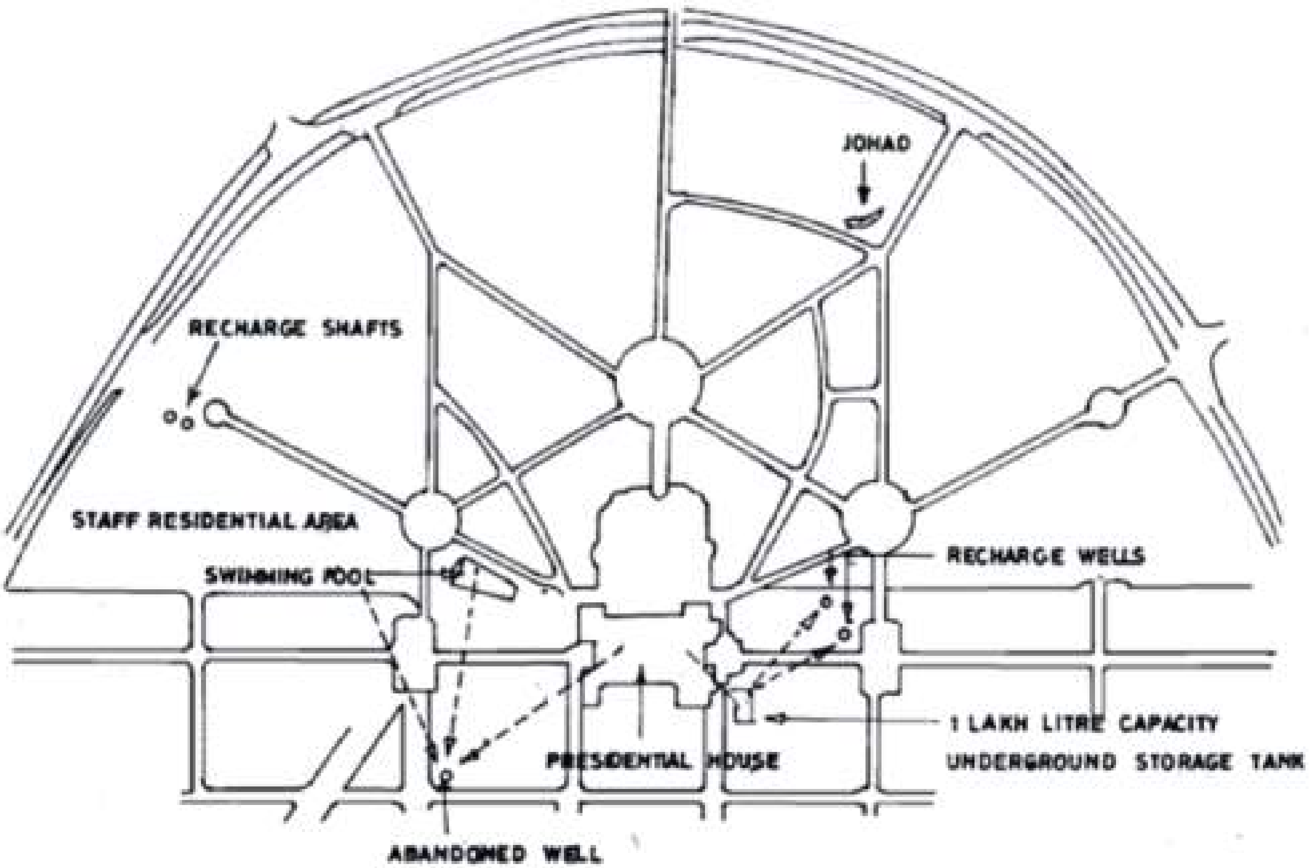


Drg. No. 6 Scheme for Water Harvesting

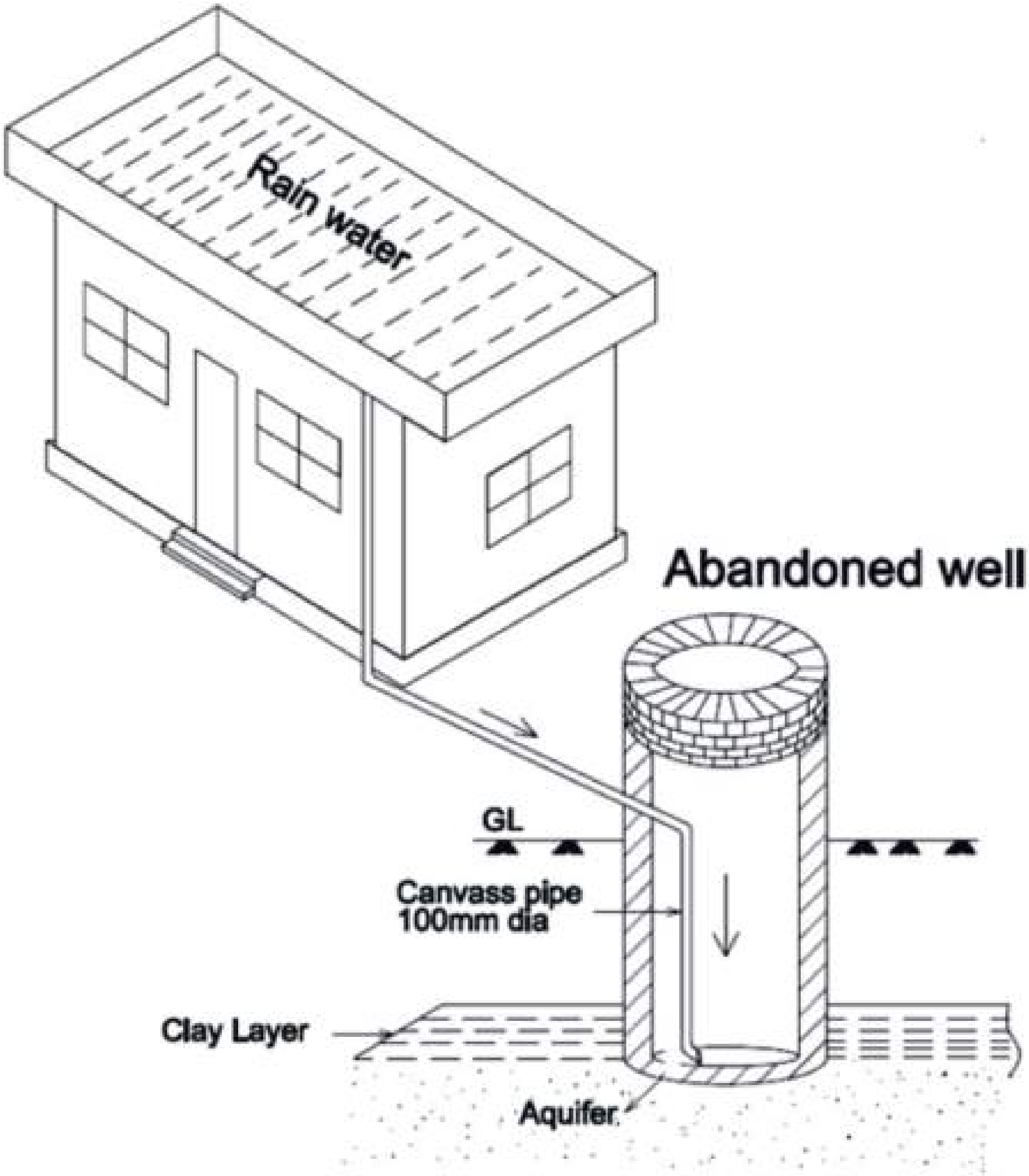


SITE PLAN

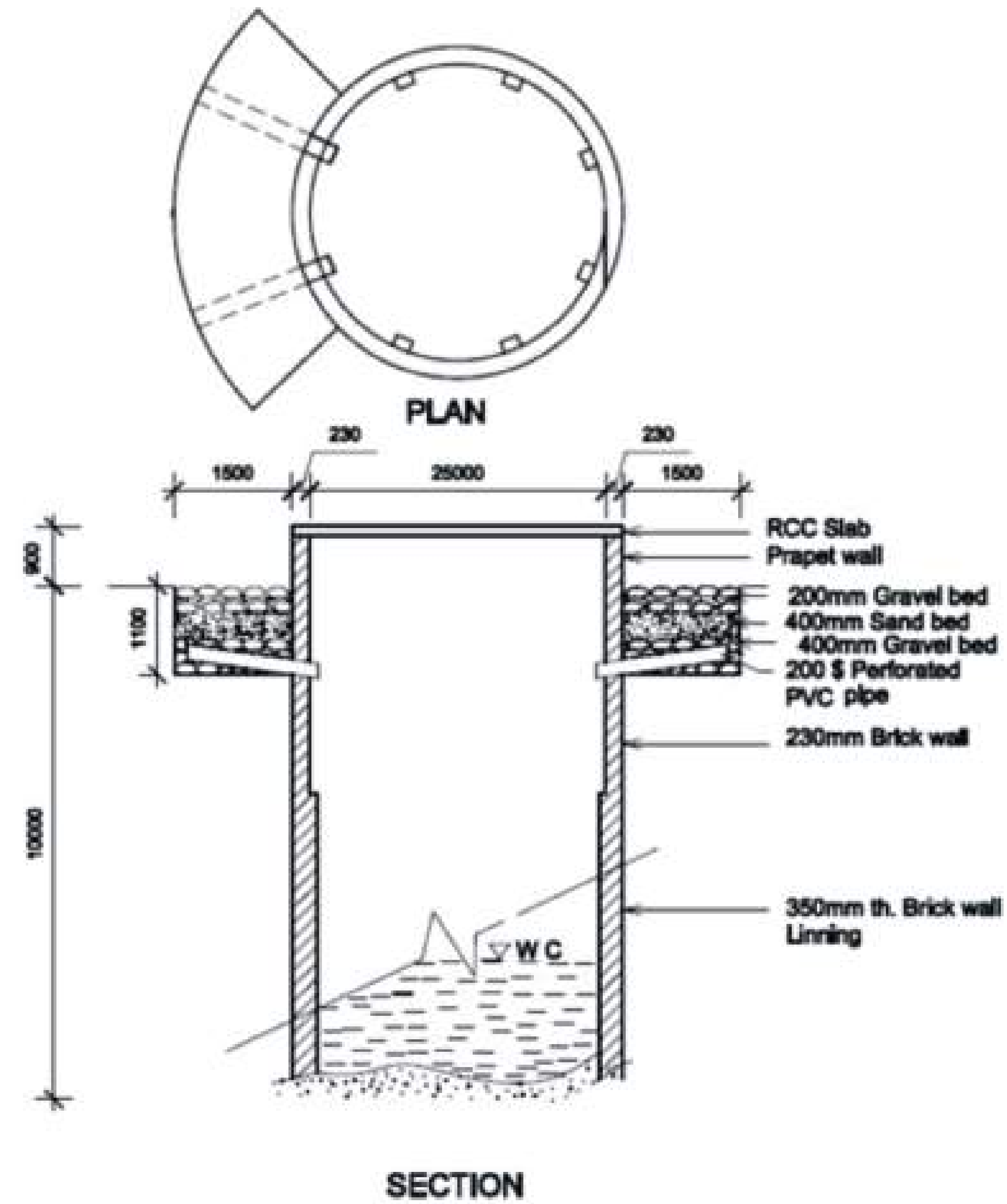
Drg. No. 7 Scheme for water harvesting



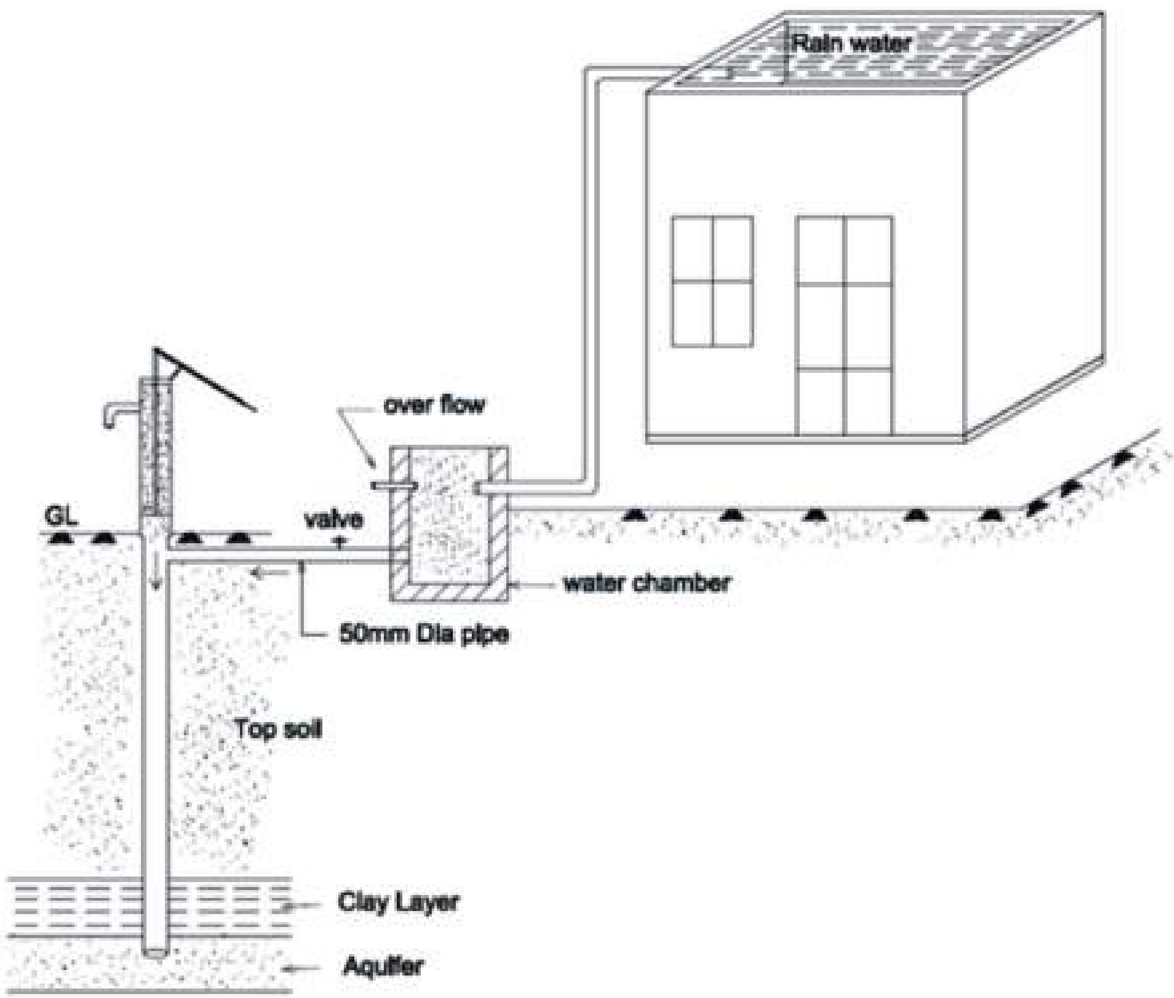
Drg. No. 8 Scheme for water harvesting



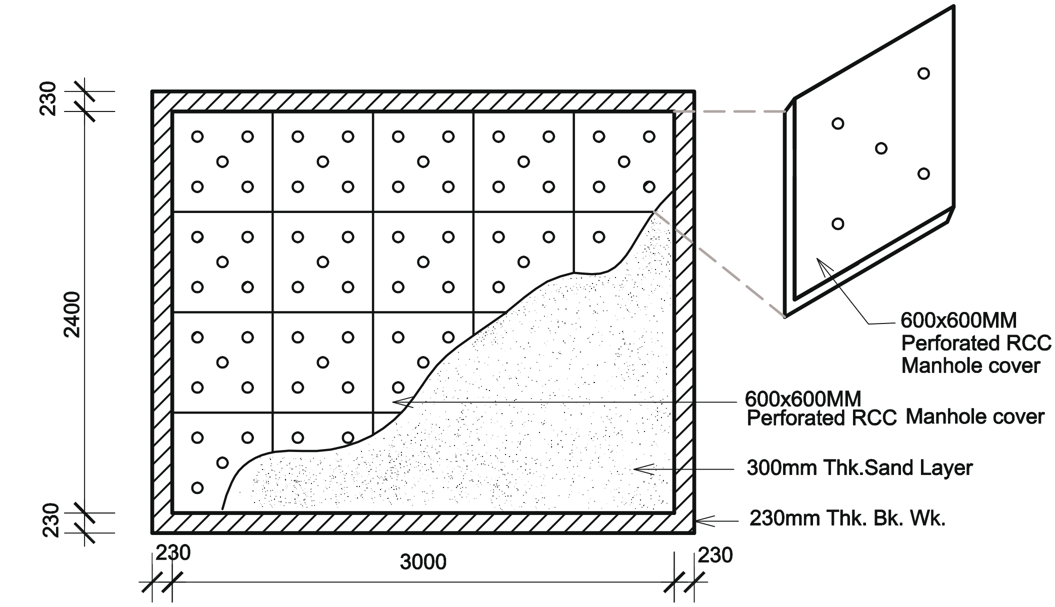
Drg. No. 9 Recharge through abandoned dug well



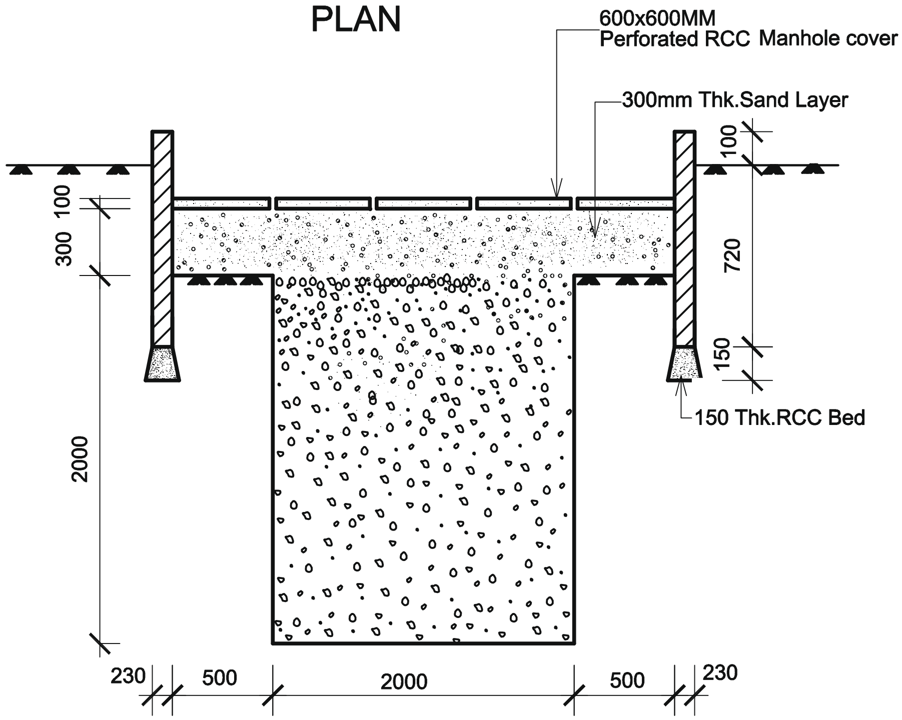
Drg. No. 10 Details of recharge dug well



Drg. No. 11 Recharge through hand pump



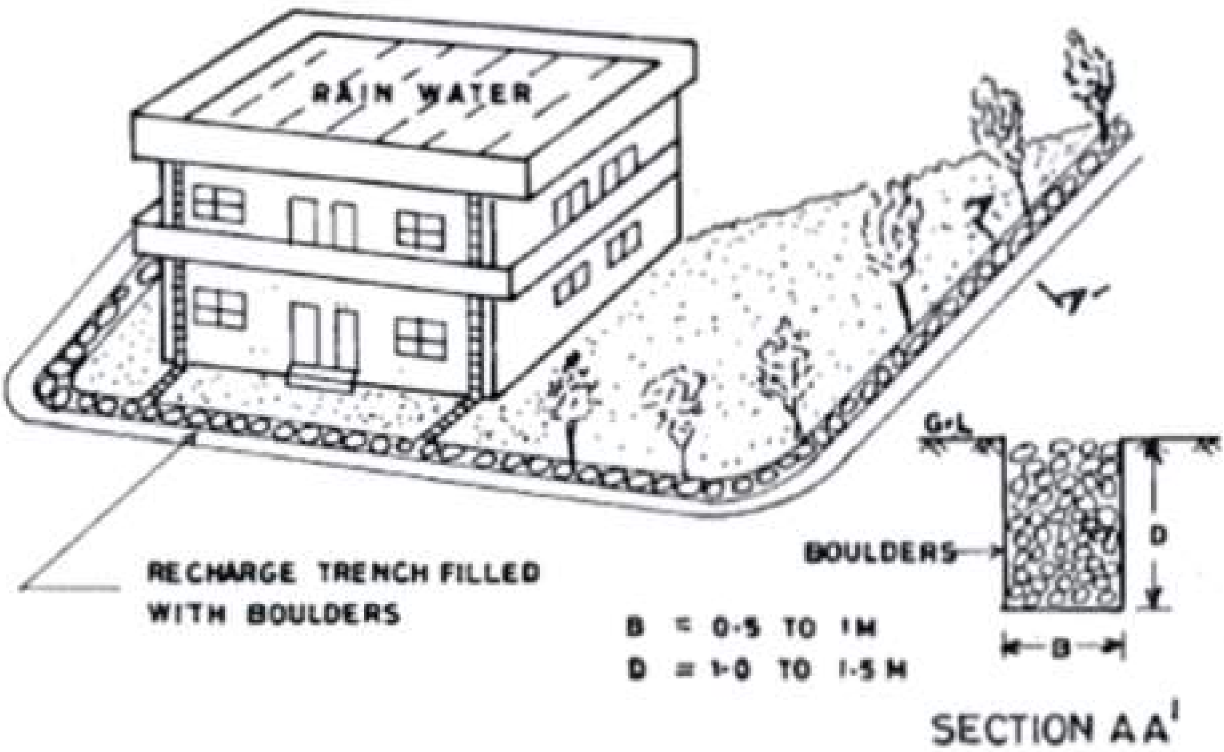
PLAN



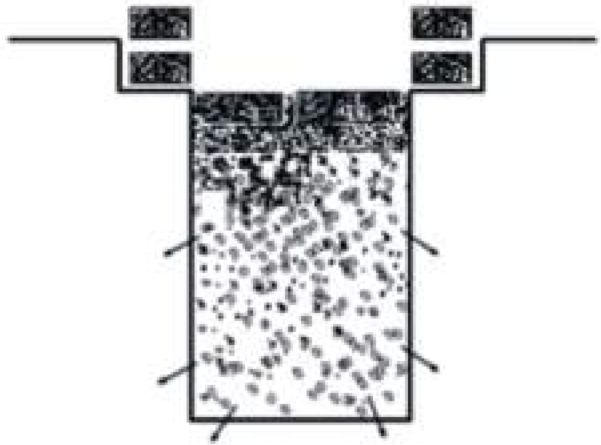
SECTION

NOTES:-
Bk.Wk :- brick work
RCC :- reinforced cement concrete
Thk :-thick
All dimensions are in mm

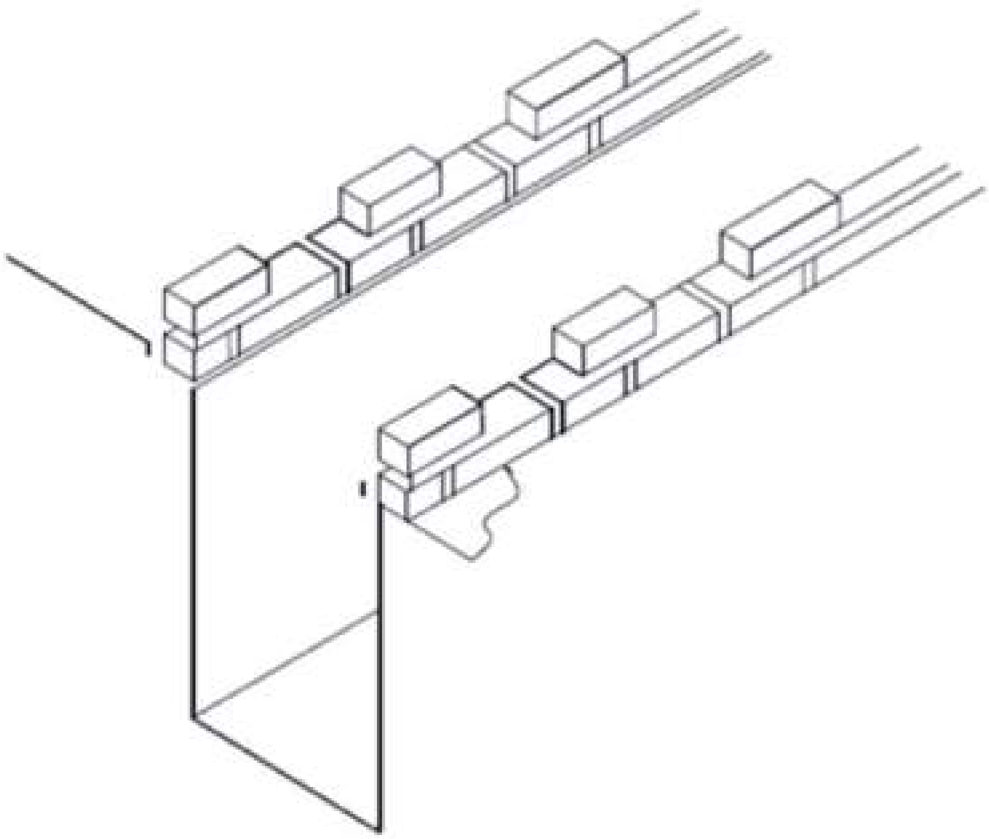
Drg. No. 12 Details of recharge pit



Drg. No. 13 Recharge through trench

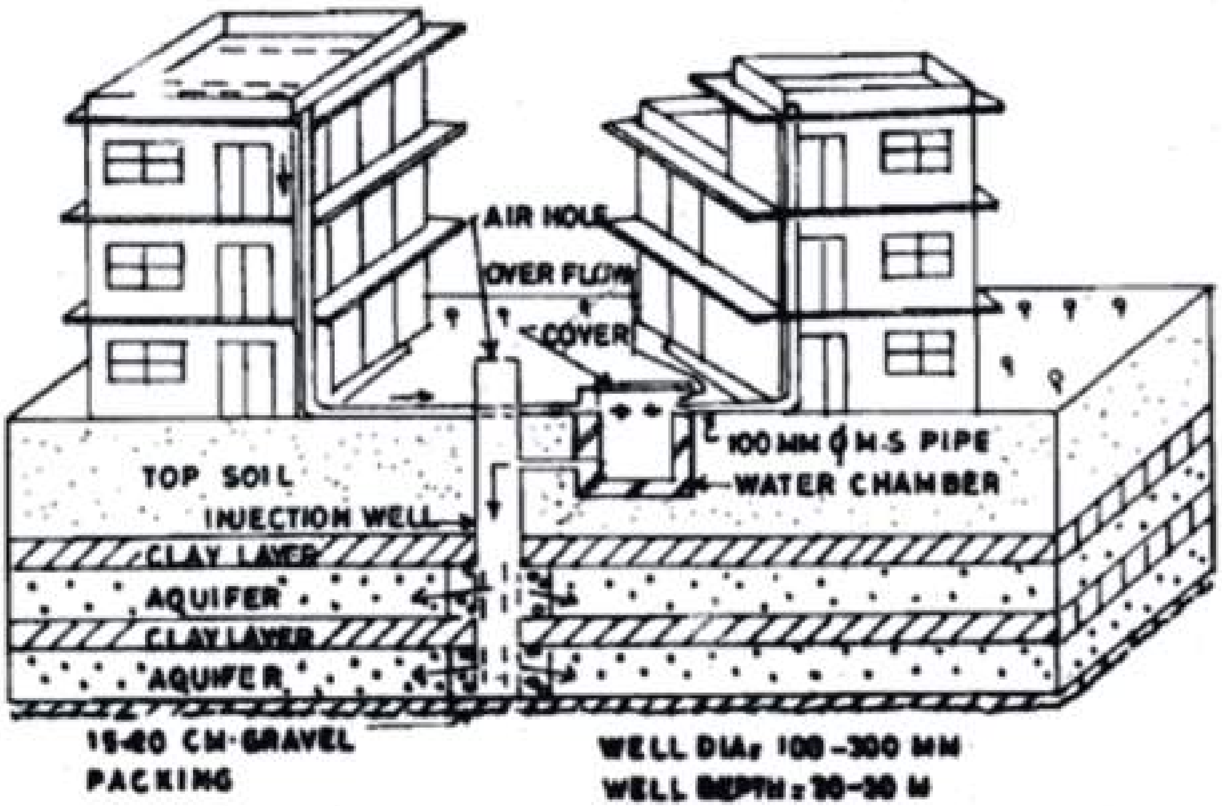


SECTION

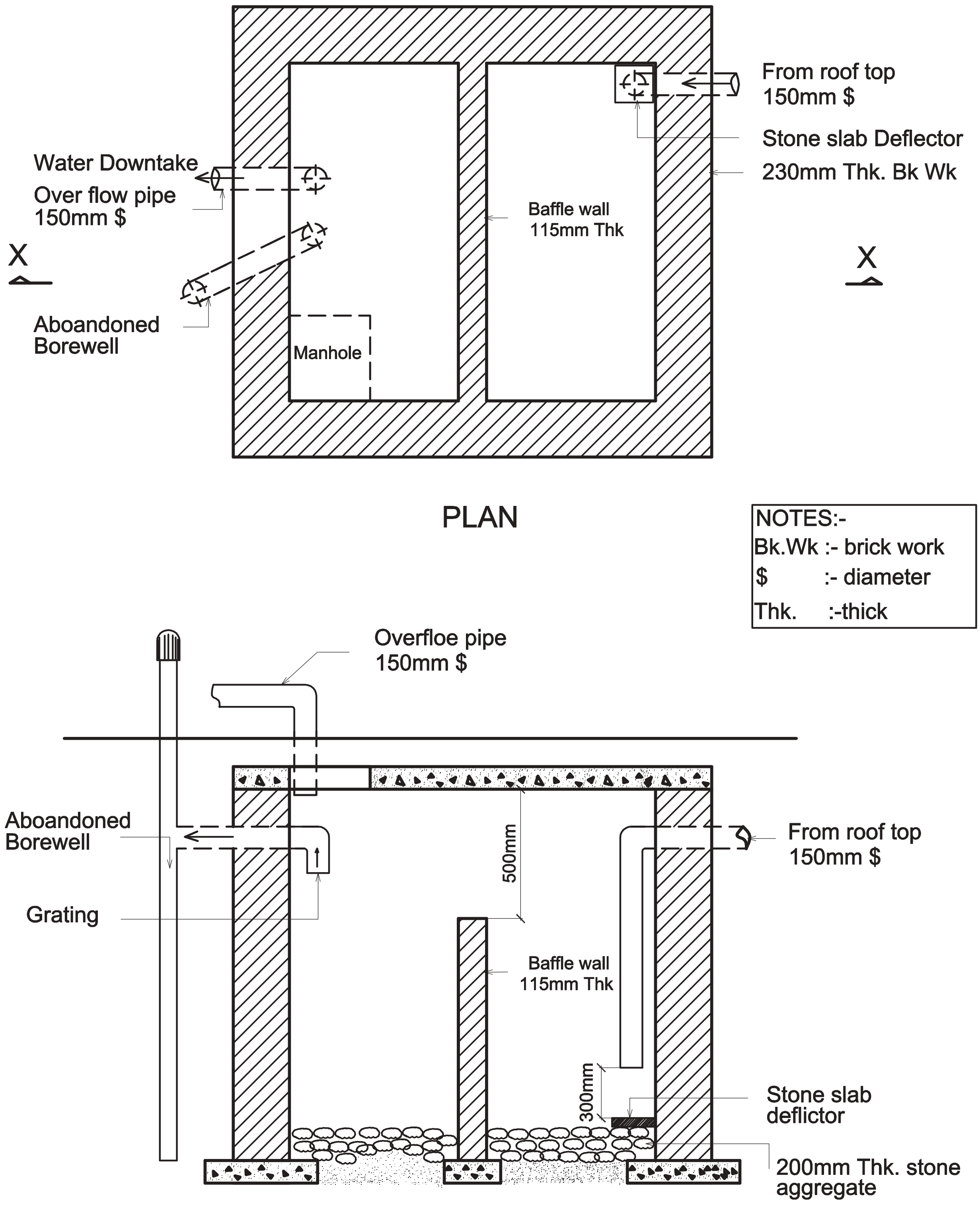


SECTION VIEW

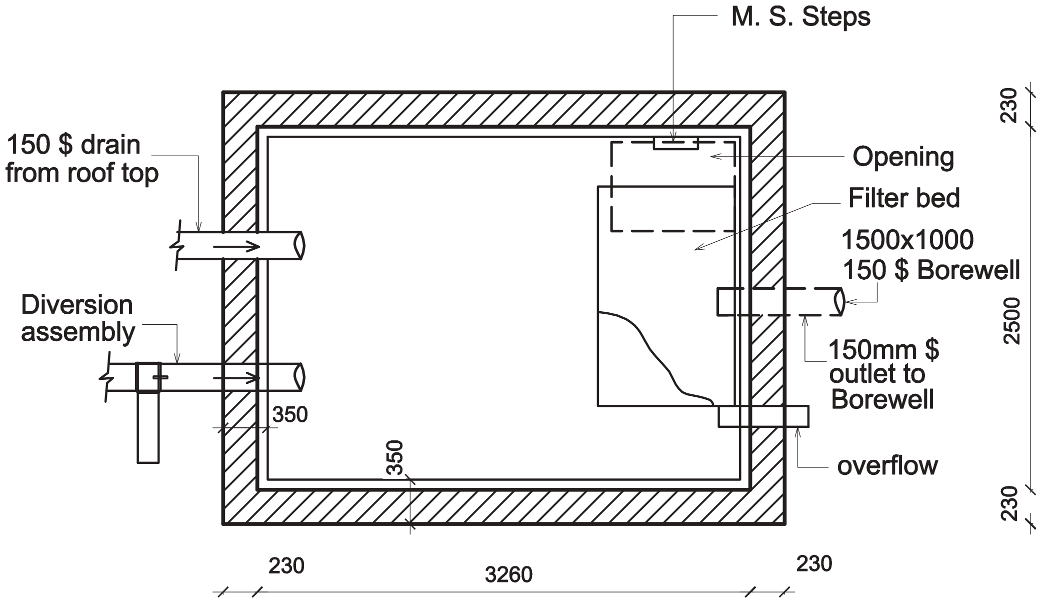
Drg. No. 14 Details of recharge trench



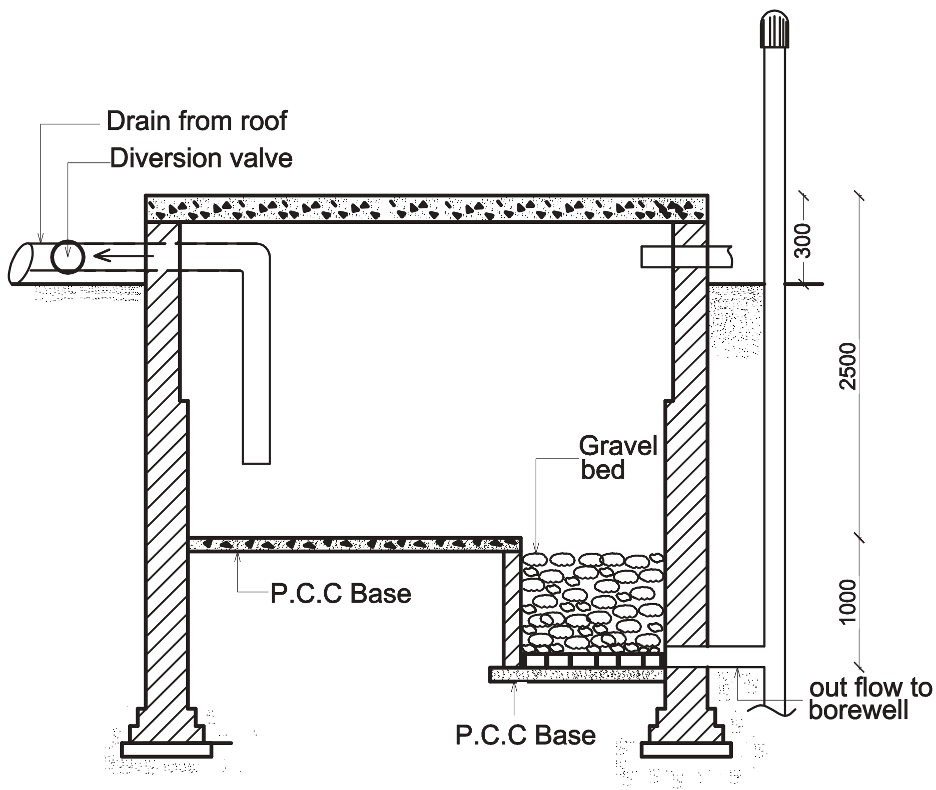
Drg. No. 15 Gravity head recharge tube well



Drg. No. 16 Details of recharge bore well and settlement tank

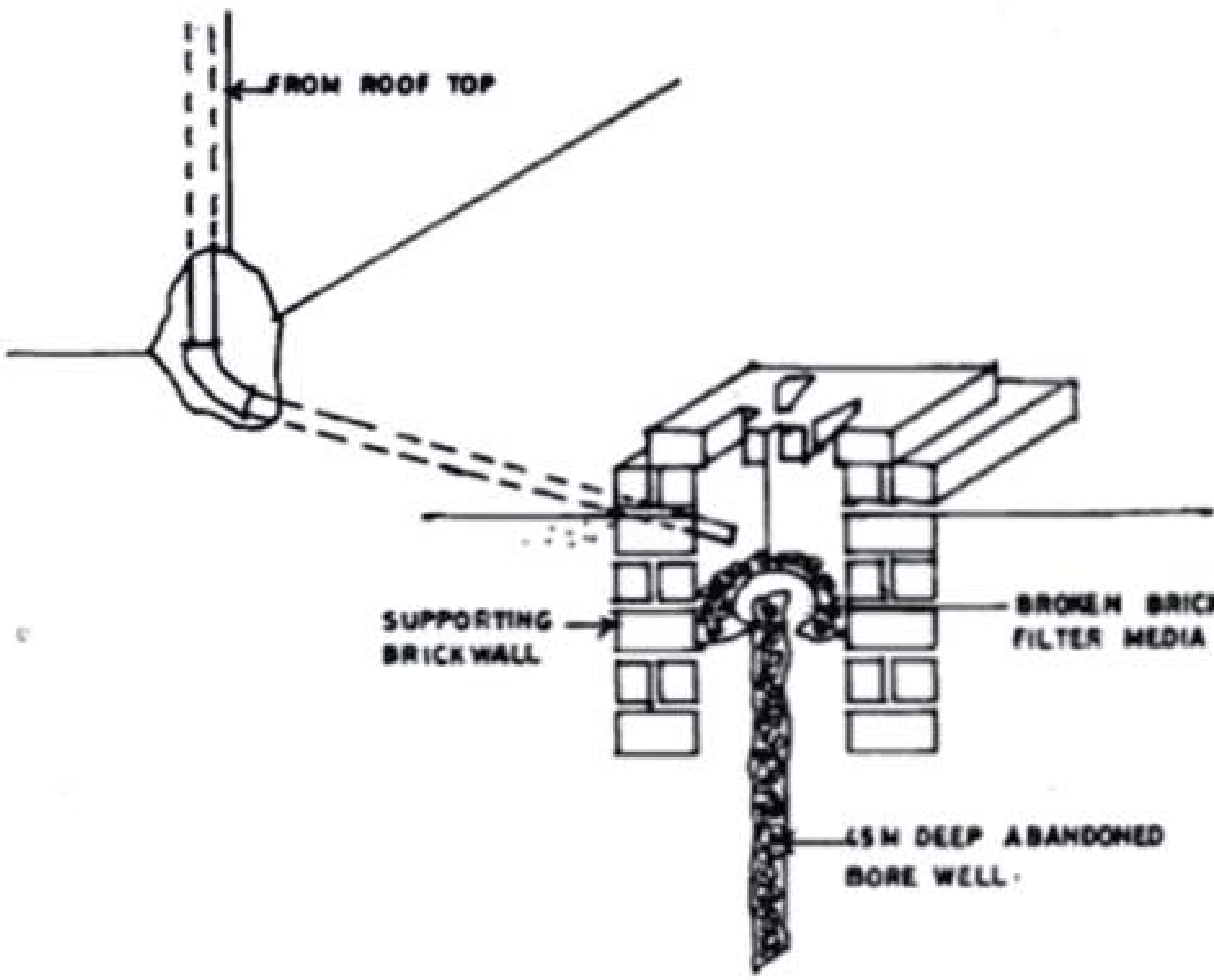


PLAN

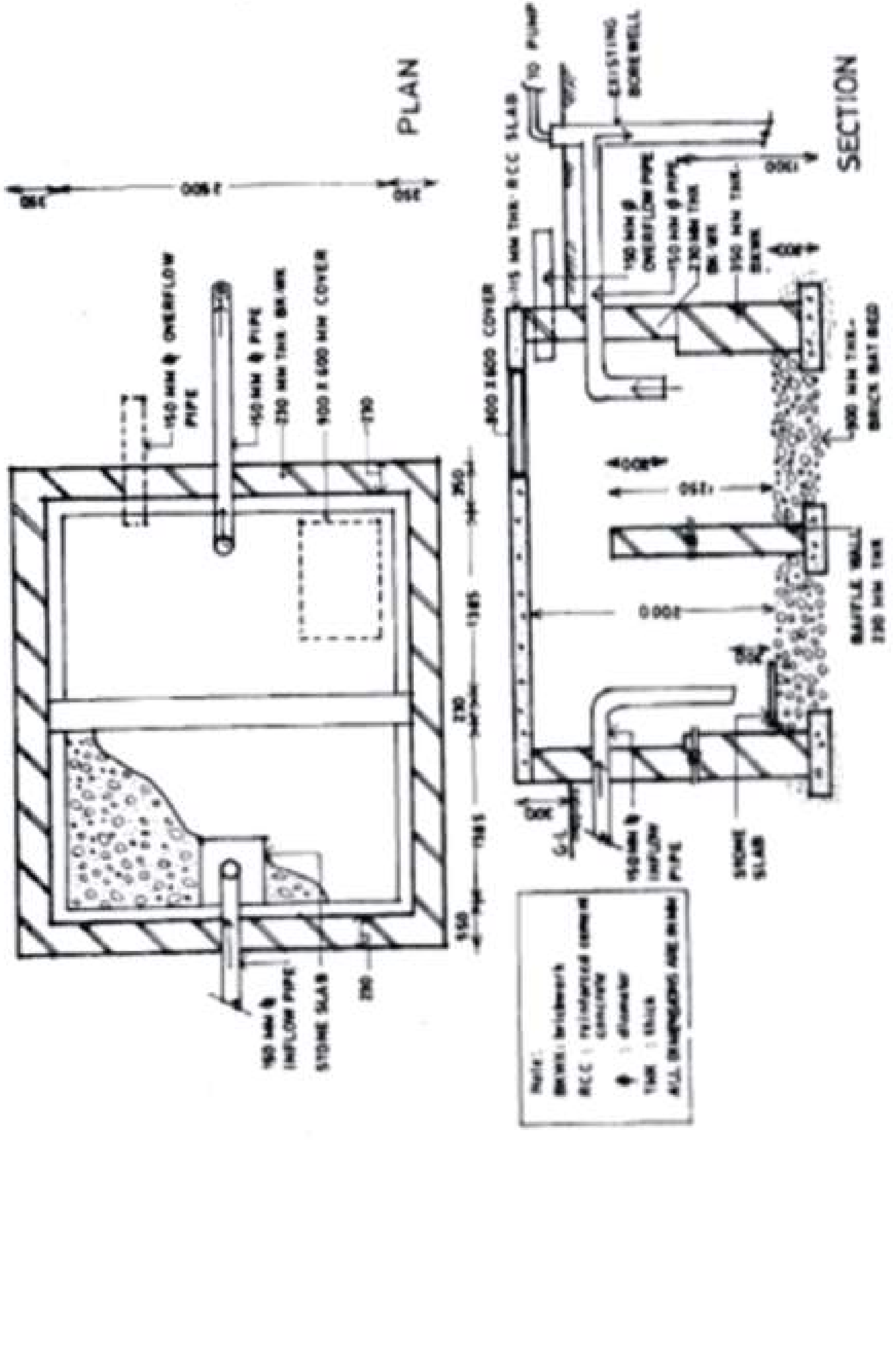


SECTION

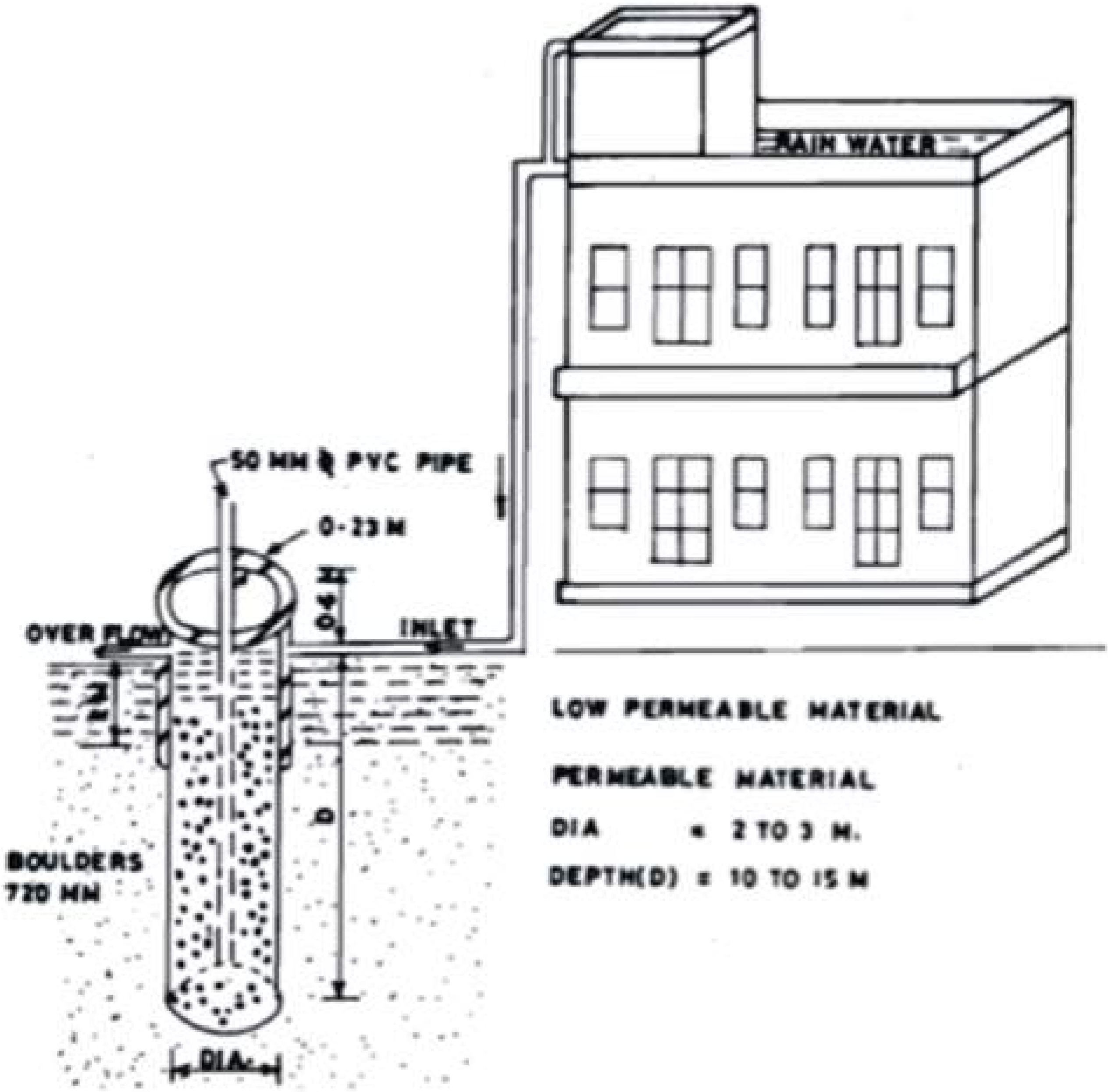
Drg. No. 17 Details of recharge bore well and filtration tank



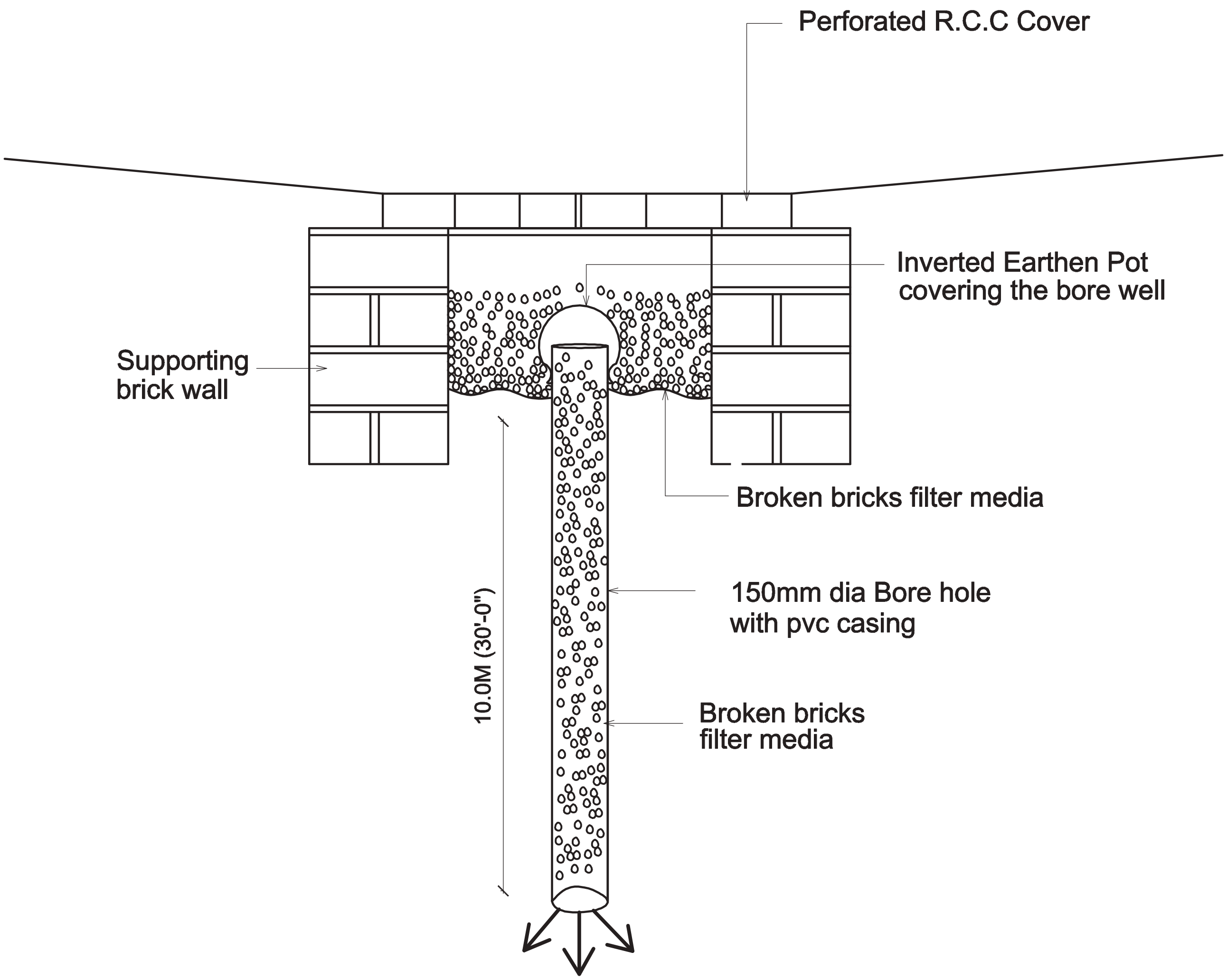
Drg. No. 18 Details of abandoned bore well recharging



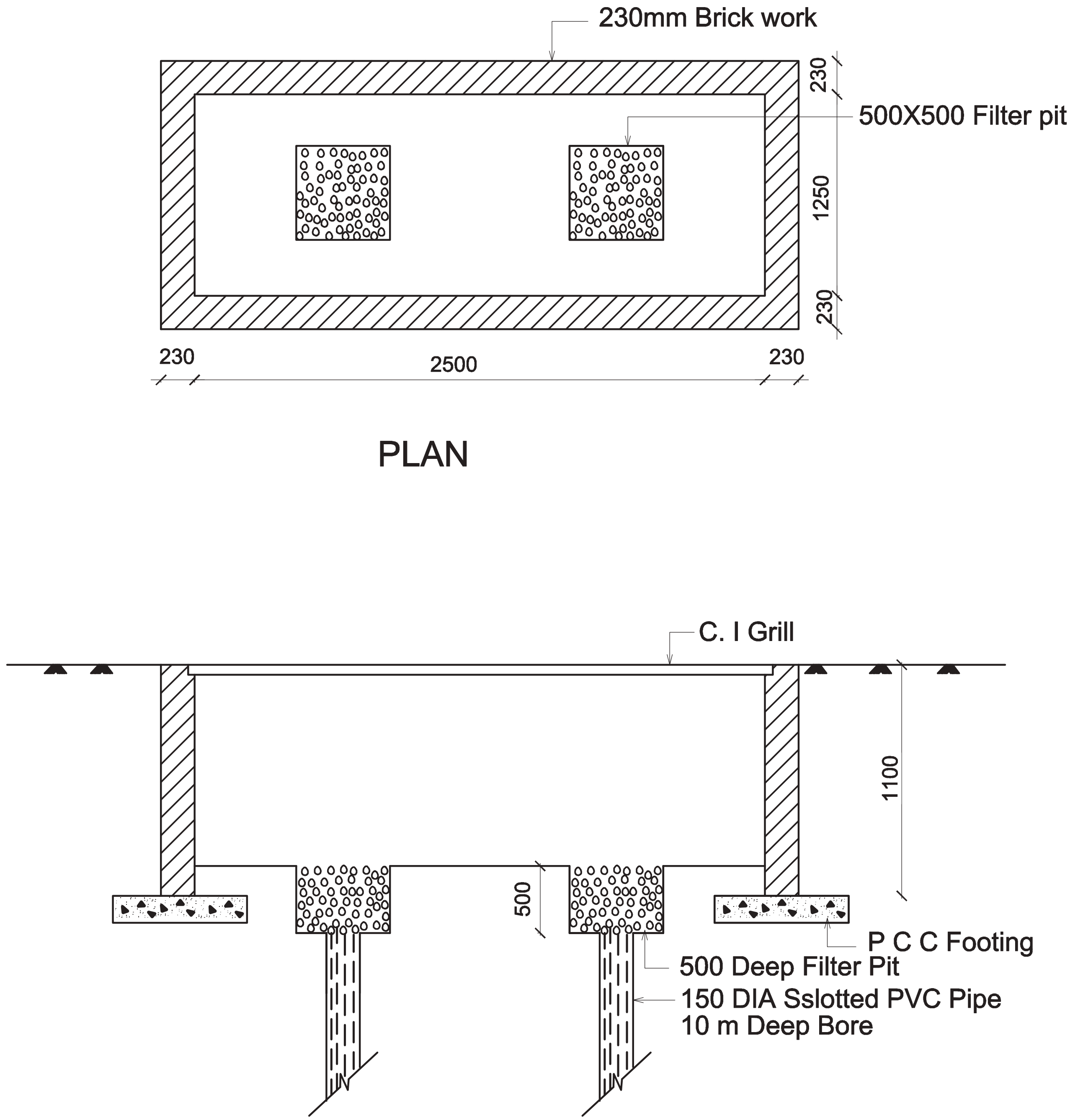
Drg. No. 19 Details of recharge bore well and settlement tank



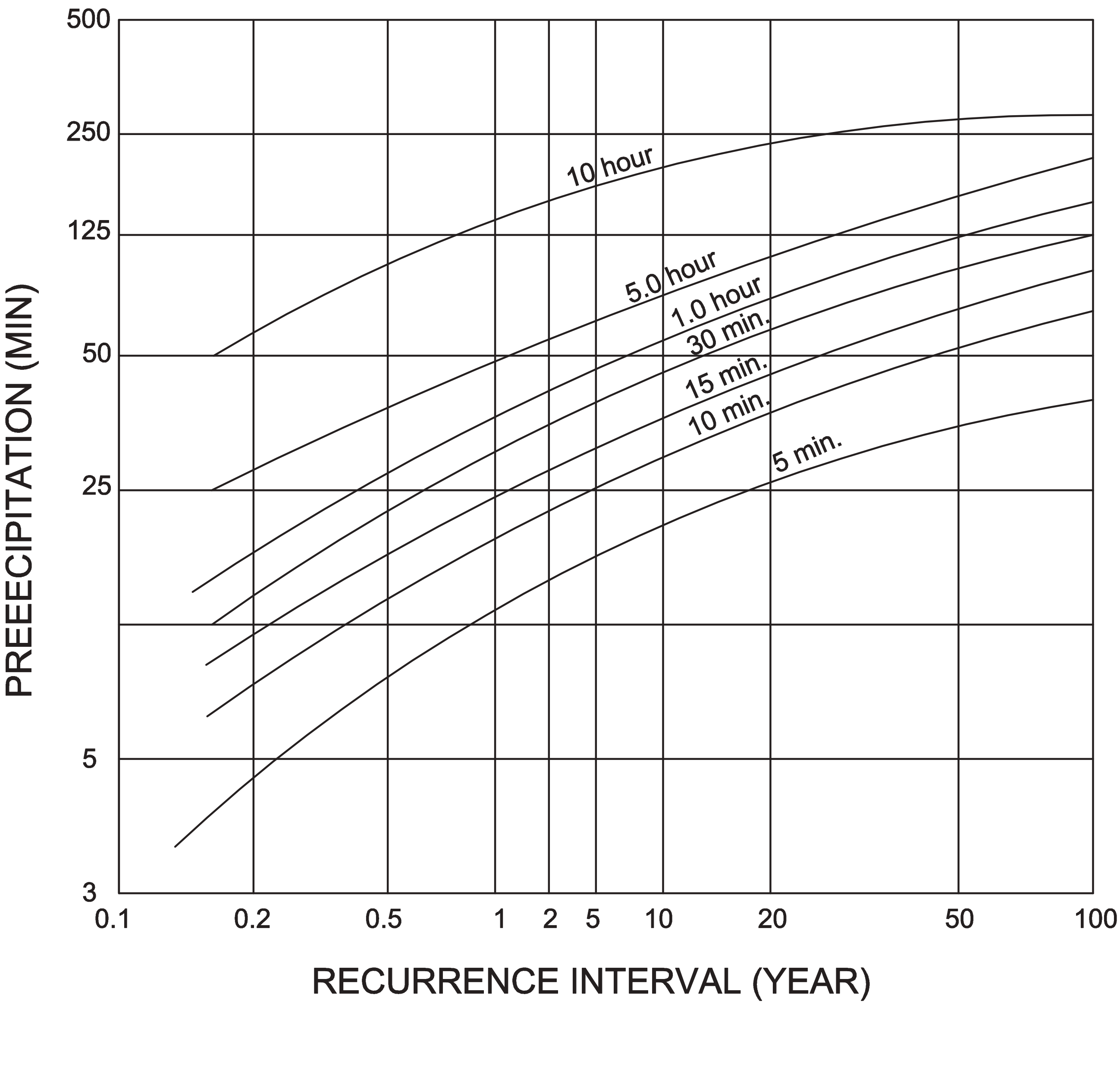
Drg. No. 20 Recharge Shaft



Drg. No. 21 Details of soakway



Drg. No. 14 Details of recharge trench



Graph No. 1 Rainfall intensity – duration – frequency relationship

CHAPTER 6

CASE STUDIES

6.1 Case No.1: SPG Project at Dwarka (Papan Kala), New Delhi.

6.1.0 Salient features:

The Rain Water Harvesting & Conservation Techniques have been successfully executed in recently completed SPG Project at Dwarka, New Delhi. The details of items executed and the drawings followed are attached in Annexure - (Case Studies). Salient features of Artificial recharge to ground water are as under:

i) Average Annual rain fall 611.8 mm

ii) Total area - 47.5 hectare

iii) Depth to water level 5.75 m bgl

iv) Water available for recharge 112419 cubic metre/annum

v) Expected recharge 80,000 cubic metre/annum

6.1.1 Aims & Objectives:

The main objectives of the schemes are as follows:

i) Augment the ground water recharge through surplus water available in the area.

ii) To arrest the rate of decline of ground water levels.

iii) To Monitor the effect and rate of ground water recharge

iv) To develop the technology for artificial recharge is specially in urban areas and also quantify the volume of recharged water.

v) To evaluate cost benefits of various recharge techniques adopted

vi) To create awareness in the society for proper management of ground water resources.

6.1.2 Availability of water

Total area complex = 47.48 hectare

Average annual rain fall is	=	611.8 mm
Total run off available for recharging the ground water	=	112419 m3 per annum
Expected run off at hourly Rain fall intensity of 40mm / hour is	=	7350.06 m3

S.No.	Area Description	Area contributing run off (sqm)	Runoff availability (cubic metre)
1	Type IV Qrs	189.04 x 35-6616	90x35=3150
2	Type V Qrs	312.82x13=4067	150x13=1950
3	Type VI Qrs	459.5x4=1838	220x4=880
4	Play Ground	181500	6000
5	Market area	6050	1700
Total		170071	13680

The ground water occurs in sandy silt horizon and predominantly kankar horizon which are potential aquifer zones in the area.

6.1.3 Type of artificial recharge structures proposed:

Recharge trenches cum recharge wells are proposed. The design of these structures are given in Drawing No.23.

Recharge wells will be used for pumping wherever recharge source water is not available.

The pumping may take care of cleaning the silt which may enter the well during recharge.

6.1.4 Benefits of scheme:

i) Proper utilisation of available run off

ii) Arresting decline ground water and intrusion of brackish water in fresh water aquifers

iii) Saving in energy for lifting of water.

iv) To provide the sustainability to sum extend to the existing near by ground water structures.

6.1.5 Attributes of Ground Water:

i) There is more ground water than surface water

ii) Ground water is less expensive and economic source

iii) Ground water is sustainable and reliable source of water supply

iv) Ground water is relatively less vulnerable to pollution, high bacteriological purity, free of pathogenic organism, needs little treatment before use

v) Ground water has no turbidity and colour, universally available

vi) Ground water source can be instantly developed and used

vii) Ground water has distinct health advantage as an alternative for lower sanitary surface water.

viii) There is no conveyance losses in ground water based supplies

ix) Ground water has low vulnerability to drought

x) Ground water is key to life in arid and semi - arid regions

xi) Ground water is source of dry weather flow in rivers and streams.

6.2 Case No. 2: Scheme for Artificial recharge to ground water at NH IV area, Faridabad (Haryana)

6.2.1 Salient features:

Normal annual Rain fall	564.3mm
Normal Monsoon Rainfall	487.4 mm in on an average 21.8 days
Geological formation	alluvial and quartzite
Depth to water level	About 26 mtr below ground level

Hydrology of the area is characterized by alluvium under lain by quartzite. Sand mixed with alluvium acts as very good repository for ground water. Depth to water level in the area is about 26 m below ground level.

6.2.2 Aims & Objectives:

i) To recharge the available runoff which accumulates around quarters and creates inconvenience to the residents.

ii) To arrest the decline of the ground water levels in the area.

iii) To create awareness in the society for proper management of rain water through harvesting.

6.2.3 Availability of surface water:

The annual normal rain fall of the area is 564.3 mm, out of which 487.4 mm occurs during monsoon period in on an average 21.8 days. The runoff availability for each block, play ground and for market area is assessed as below:

S.No.	Area Description	Area contributing run off (sqm)	Runoff availability (cubic metre)
1	Type IV Qrs	189.04 x 35 6616	90x35=3150
2	Type V Qrs	312.82x13=4067	150x13=1950
3	Type VI Qrs	459.5x4=1838	220x4=880
4	Play Ground	181500	6000
5	Market area	6050	1700
Total		170071	13680

Thus about 13680 cum runoff is available annually for recharge to ground water.

6.2.4 Type of artificial recharge structures proposed:

The structures should be constructed only at those places where water accumulates during monsoon period. The proposed recharge structures may be constructed at lower elevations keeping the topography into consideration.

6.2.5 Benefits of scheme:

I) Proper utilization of the available run off which accumulates around the quarters

ii) To increase soil moisture

iii) Sustaining the green areas

iv) Arresting the declining ground water level

v) Provide sustainability to the existing ground water absorption structures in the area.

Structures 1, 2, 3 *(Ref. Drawing No. 24 to 26)* Recharge pit with Bore

Structure 4 (Lateral shaft with bore wells) *(Ref. Drawing No.27)*

6.3 Case No. 3: Artificial recharge at Sewa Bhawan, RK Puram, New Delhi.

Average Annual rain fall	712.2 mm
Average Monsoon rain fall	605.2 mm
Geological formation	Older alluvial
Depth to water level	16 - 20 m bgl.
Water available for recharge	4500 cum
Expected recharge	4000 cum
Recharge structures proposed	4 recharge trench with injection wells (See Drawing No.28 & 29)

6.4 Case No. 4: Artificial recharge proposal at HUDCO Place, Andrews Ganj, New Delhi.

6.4.1 Salient features:

Total Campus area	11.61 hectare
Normal Annual rainfal	712.2mm
Normal Monsoon rain fall	605.2 mm
Geological formation	Alluvium
Depth to water level	About 24 m BGL

Hydrology of the area is a plain country having a very gentle northerly slope. The general elevation of the area is 214 mtr above Mean Sea level. The area is underlain by alluvial soil consisting of mostly clay silt mixed with kankar with occasional Badarpur Sand and Gravel. The thickness of alluvial layer varies between 70 mtr -100 mtr B.G.L. Depth of water level in the area is about 24 mtr. B.G.L.

6.4.2 Aims & Objectives: The main objectives of the scheme are:

i) To augment the ground water recharge through surplus water in the area.

ii) To arrest the decline of the ground water levels in the area.

iii) To create awareness in the society for proper management of ground water resources.

6.4.3 Availability of water:

Water available for recharge 50350 cum

6.4.4 Type of artificial recharge structure proposed:

Recharge structure proposed Trench cum bore wells-7

Specification of Filter Material (See Drawing No.30 & 31)

a) Coarse Sand 1.5 to 2mm size

b) Gravel 5 to 10 mm size

c) Boulders Rounded and 5 to 20 cm

Depth & Dia of Recharge wells 32 m & 12" (303 mm)

Design of Recharge wells

S.No.	Depth range	Assembly
1.	0.00 to 0.50 m B.G.L.	303 mm dia. MS blank pipe
2.	0.00 to 1.5 m B.G.L.	303 mm dia. MS blank pipe
3.	1.5 to 2.5 m B.G.L.	303 mm dia slot pipe of 3 mm size
4.	2.5 to 10.00 m B.G.L.	303 mm dia M.S. blank pipe
5.	10.00 to 18.00 m B.G.L.	303 mm dia MS slot pipe of 1.59 mm size
6.	18.00 to 20.00 m B.G.L.	303 mm dia blank pipe
7.	20.00 to 30.00 m B.G.L.	303 mm dia slotted pipe of 1.59 mm size
8.	30.00 to 32.00 m B.G.L.	303:mm dia blank pipe with bail plug

Availability of surface water

Structure No	Area in Sqm	Runoff (m^3)
1.	11772	5220.00
2.	9300	4251.00
3.	13273	3618.00
4.	9640	4486.00
5.	11250	5045.00
6.	11250	5046.00
7.	749615	22684.00
Total	116100	50350.00

Artificial recharge structure

To harness the available runoff, 7 recharge trench cum bore wells are proposed. The location and design of these structures are given in Drawing No. 30 to 31.

6.4.5 Benefits of the Scheme

i) Proper utilization of available run off

ii) To increase soil moisture

iii) To sustain green areas

iv) To arrest the declining ground water level

v) To provide sustainability to the existing ground water abstraction structures in the area.

6.5 Case No.5 Ground Water recharging works at Shivajirao S. J. College of Engineering and Technology, Thane, Maharashtra.

To apply the concept of rain water harvesting to existing building, the campus of Shivajirao S. Jondhale College Of Engineering And Technology, Asangaon, Dist. Thane, have been selected. In this campus there are total 4 buildings, in which two buildings having two wings and rest of are single wings. For this buildings Water demand calculations and quantity of Rain water harvesting is calculated only for two building by considering working days, holidays, population, and terrace areas of each building.

6.5.1 Water demand calculation

Table No.1 Engineering Degree Building (Wing-A & Wing-B)

Sr No	Items	Available Population	Total Working Duration (day's)	Non Working Duration (day's)	Net Working Duration (day's)	Water Demand Litres/ Head/ Day	Total Water Demand Litres/ Head/ Day
1.	Semester (lectures)	1600	210	56	154	25	6160000
2.	Examination	1600	90	24	66	5	528000
3.	Vacations (for students)	160	60	16	44	5	35200
Total water demand for engg. Degree building in one academic year (in liters)							6723200
Total water demand for engg. Degree building per week (in liters)							129292
Total water demand for engg. Degree Building per day (in liters)							18420

Table No. 2- Polytechnic Building (Wing-A & Wing-B)

Sr No	Items	Available Population	Total Working Duration (day's)	Non Working Duration (day's)	Net Working Duration (day's)	Water Demand Litres/ Head/ Day	Total Water Demand Litres/ Head/ Day
1.	Semester (lectures)	1984	210	56	154	25	7638400
2.	Examination	1984	90	24	66	5	654720
3.	Vacations (for Students)	60	60	16	44	5	13200
Total water demand for polytechnic building in one academic year (in liters) =							8306320
Total water demand for polytechnic building per week (in liters) =							159737
Total water demand for polytechnic building per day(in liters) =							22757

As per above water demand calculations,

Total water demand for a academic year = 15029520 Liters

Total water demand for per week = 289029 Litres

Total water demand for per day = 41177 Liters

Table No.3 Calculations for Water Harvesting Potential

Sr.No	Building Description	Catchment (terrece) Area (sq.m)	Avera Ge Height Of Rainfa Ll (m)	Runof F Coffic Ient	Collected Volume of Rainfall (cu.m)	Collecte D volume Of Rainfall (litres)
1	Engineering Degree Building (Wing-A & Wing-B)	6780.25	2.2	0.9	13424.9	13424895
2	Polytechnic Building (Wing-A & Wing-B)	2784.01	2.2	0.9	5512.3	5512340

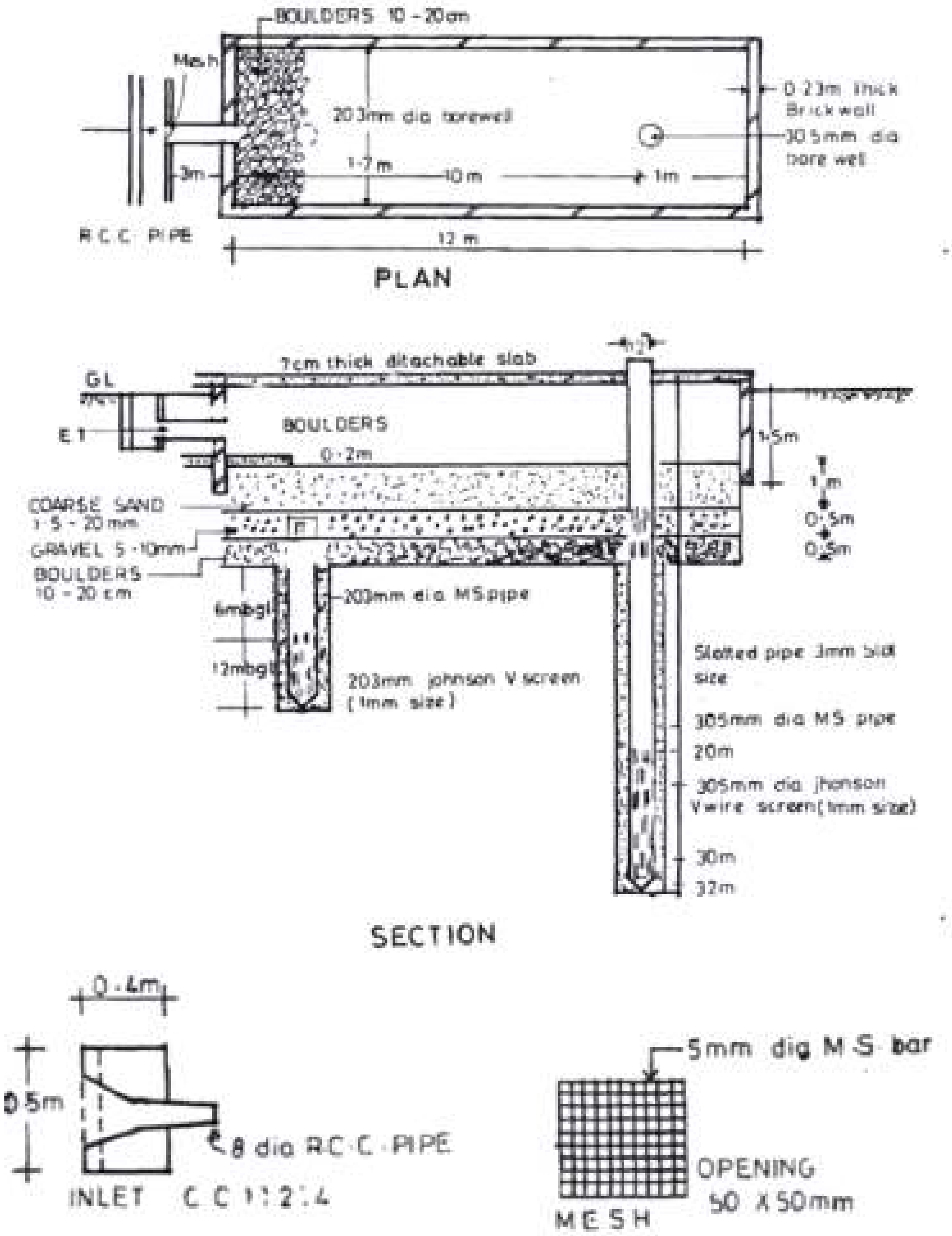
As per above water potential calculations,

Total collected volume of rainfall in year=18937235 liters

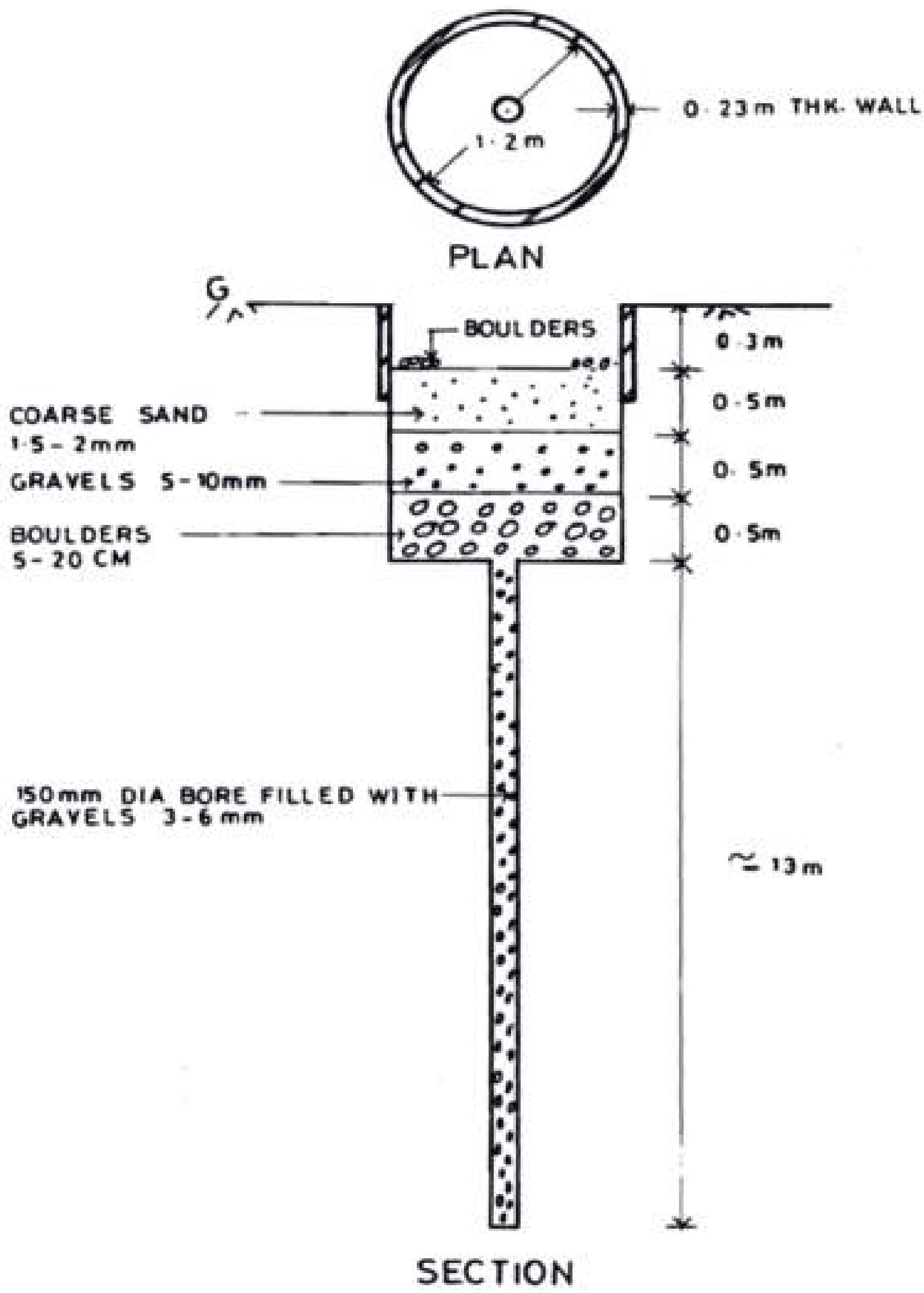
Assuming 20% losses in collection=3787447 litres

Total water available for harvesting in year =15149788 litres

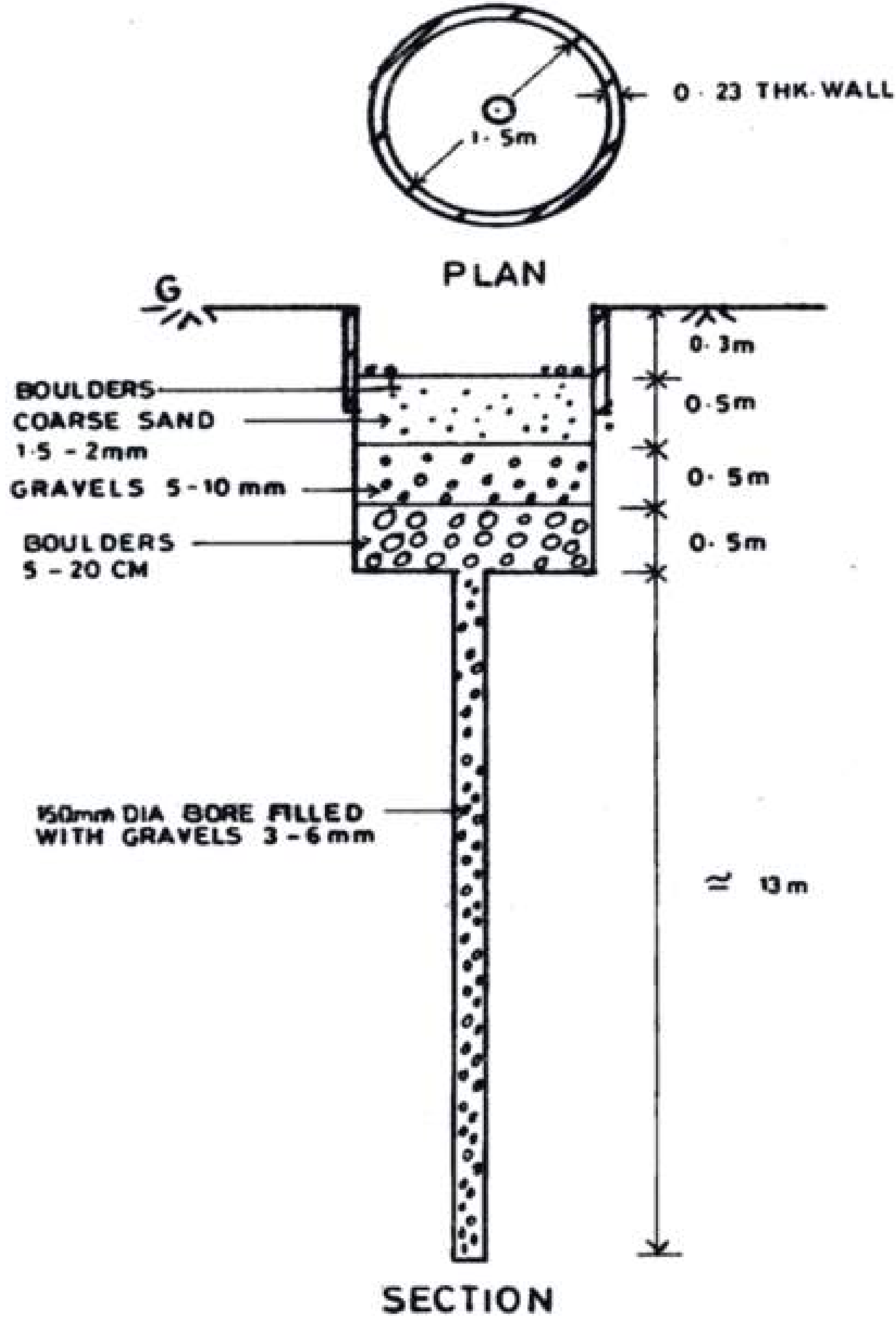
Thus, as per the calculation, we can save more water than demand.



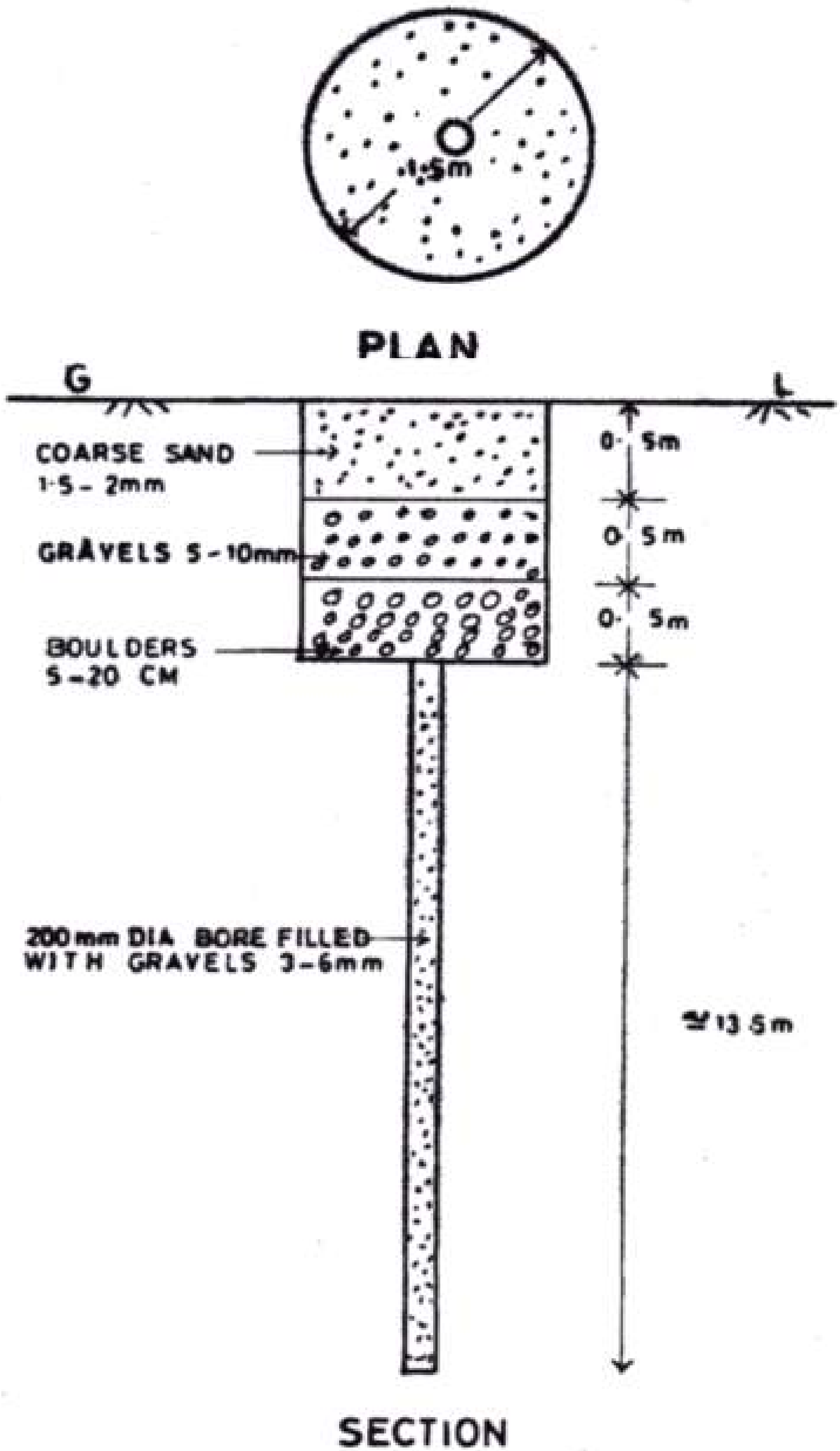
Drg. No. 23 Size of recharge trench cum recharge wells



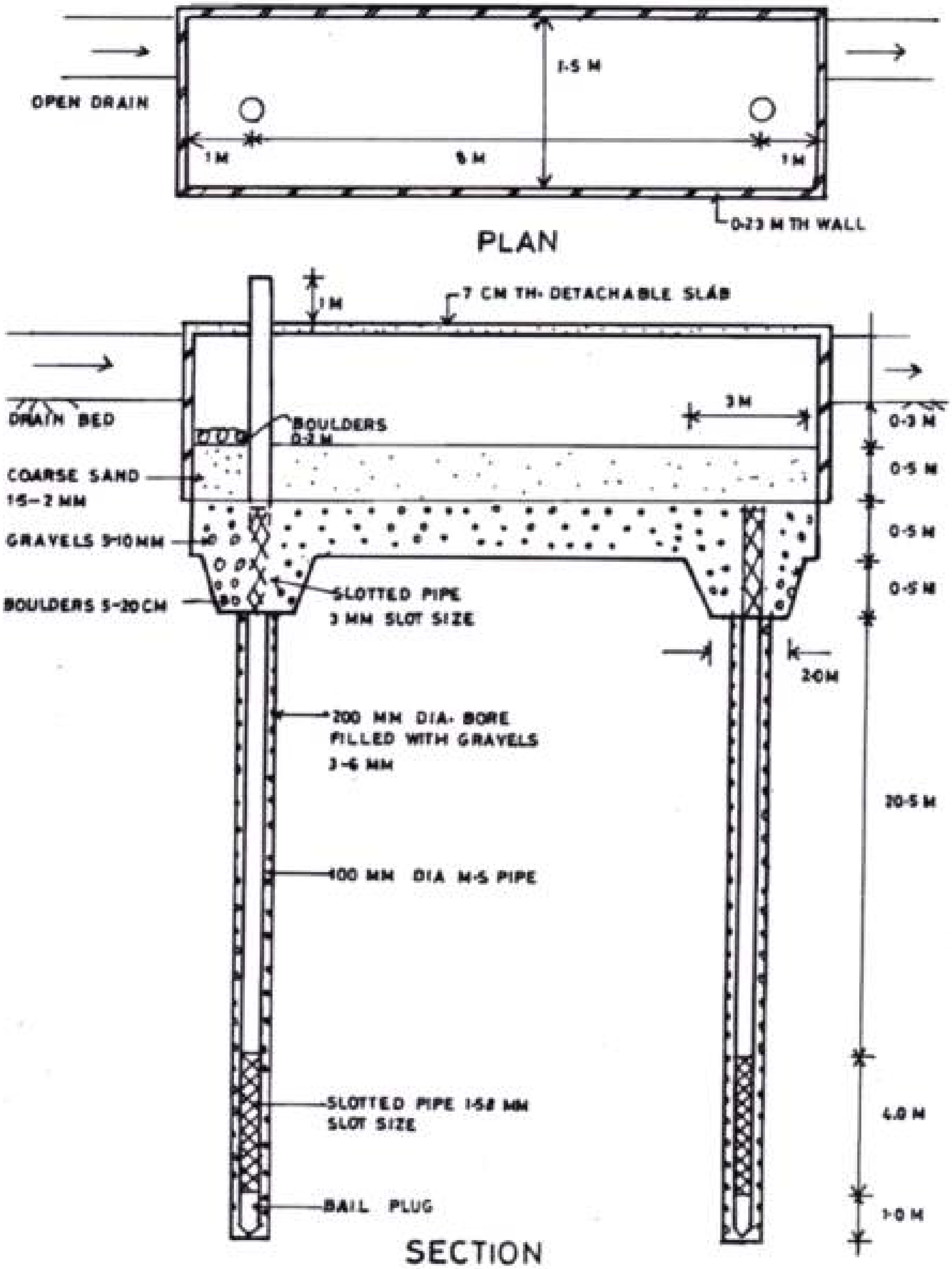
Drg. No. 24 Structure-1 (Recharge pit with bore)



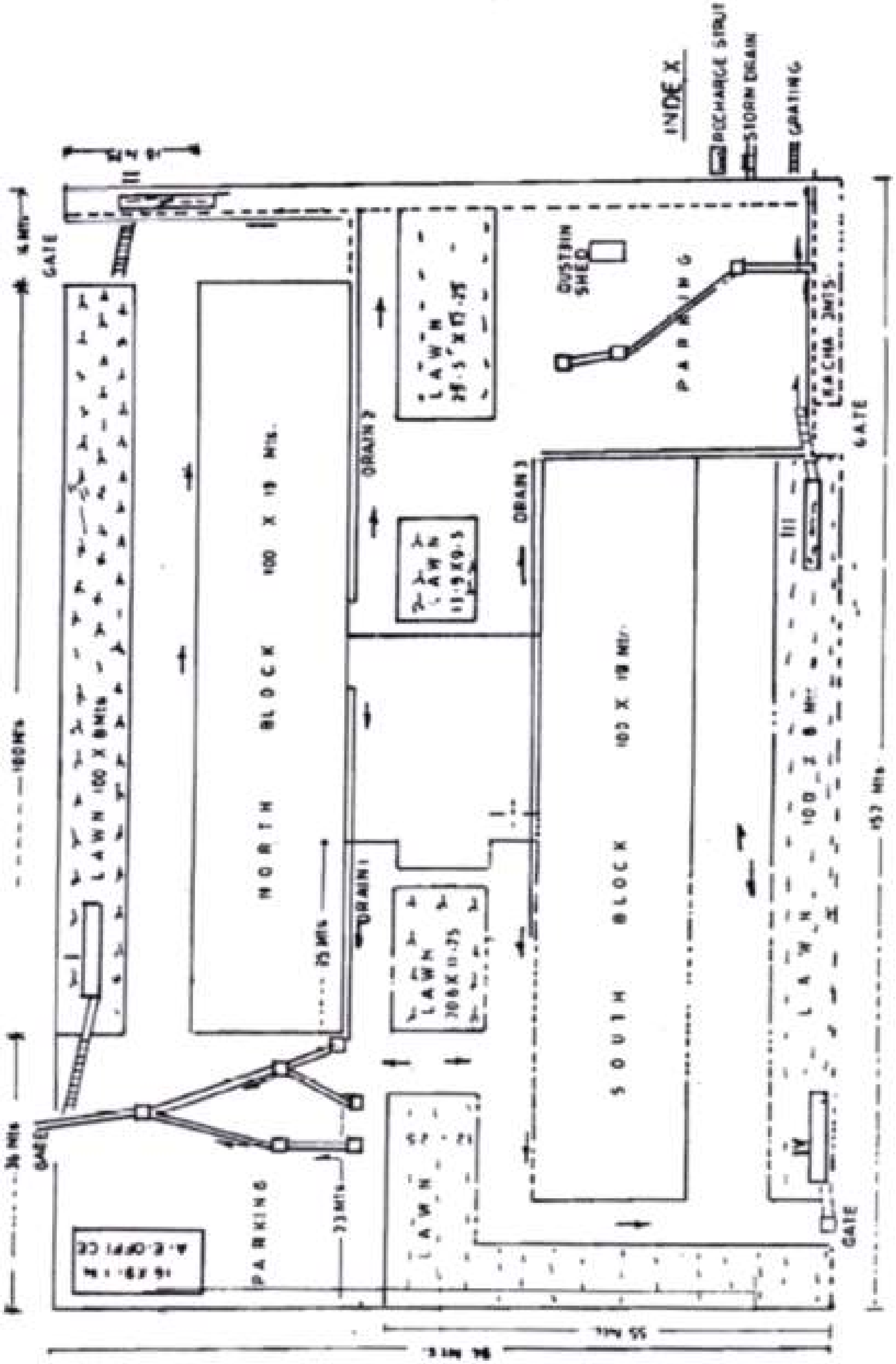
Drg. No. 24 Structure-1 (Recharge pit with bore)



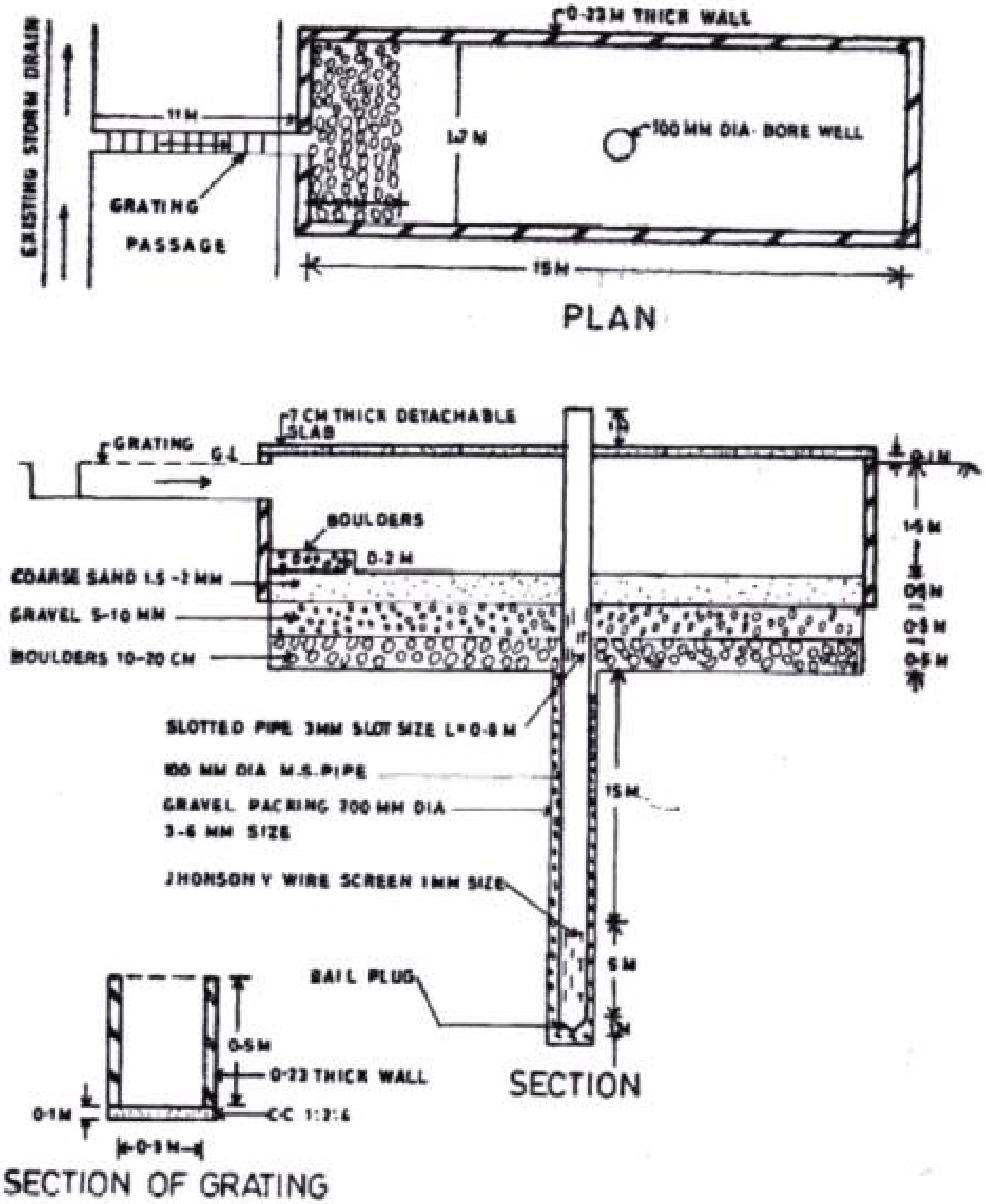
Drg. No. 26 Structure-3 (Recharge pit with bore)



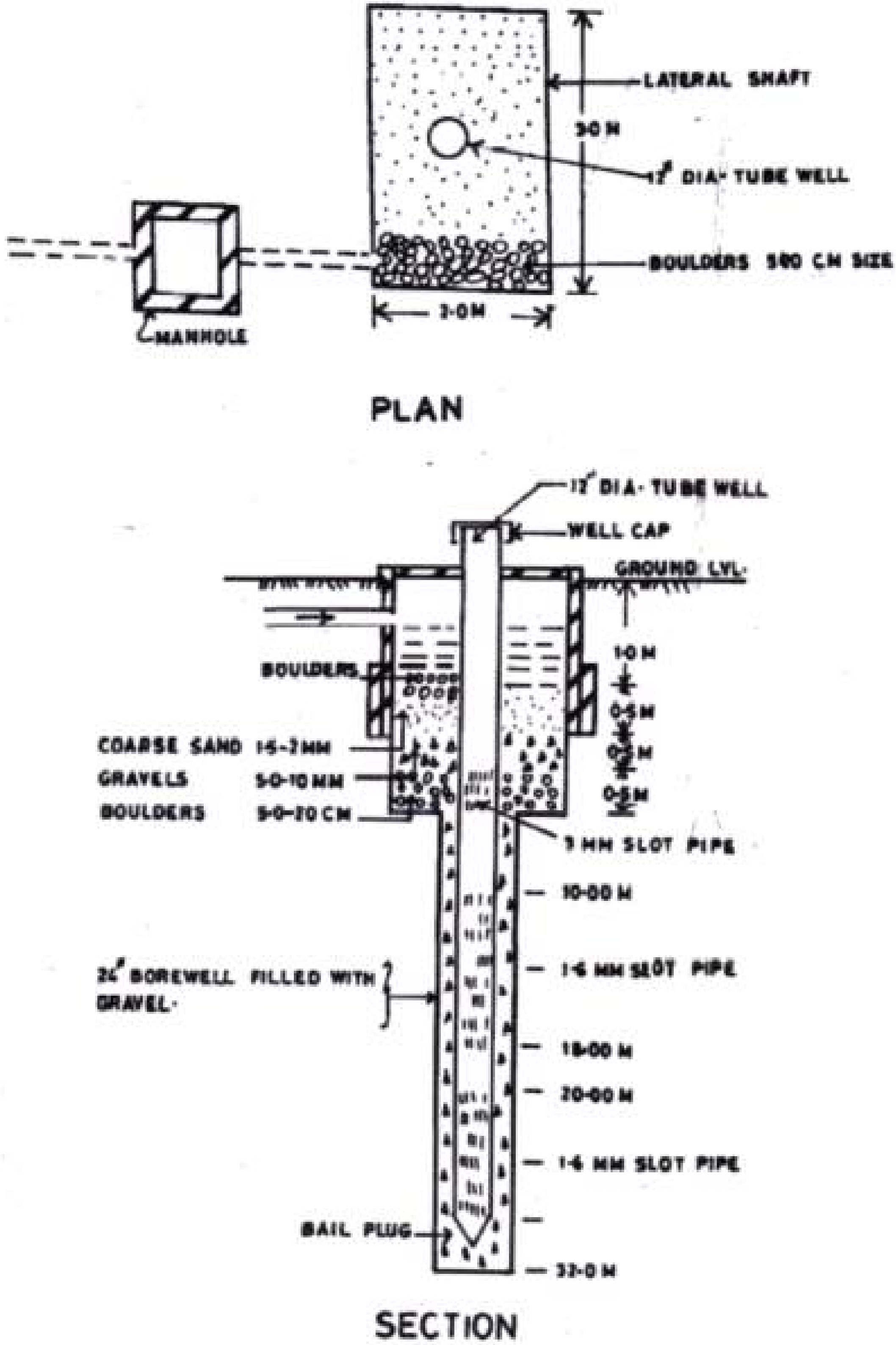
Drg. No. 27 Structure - 4 (Lateral shaft with bore wells)



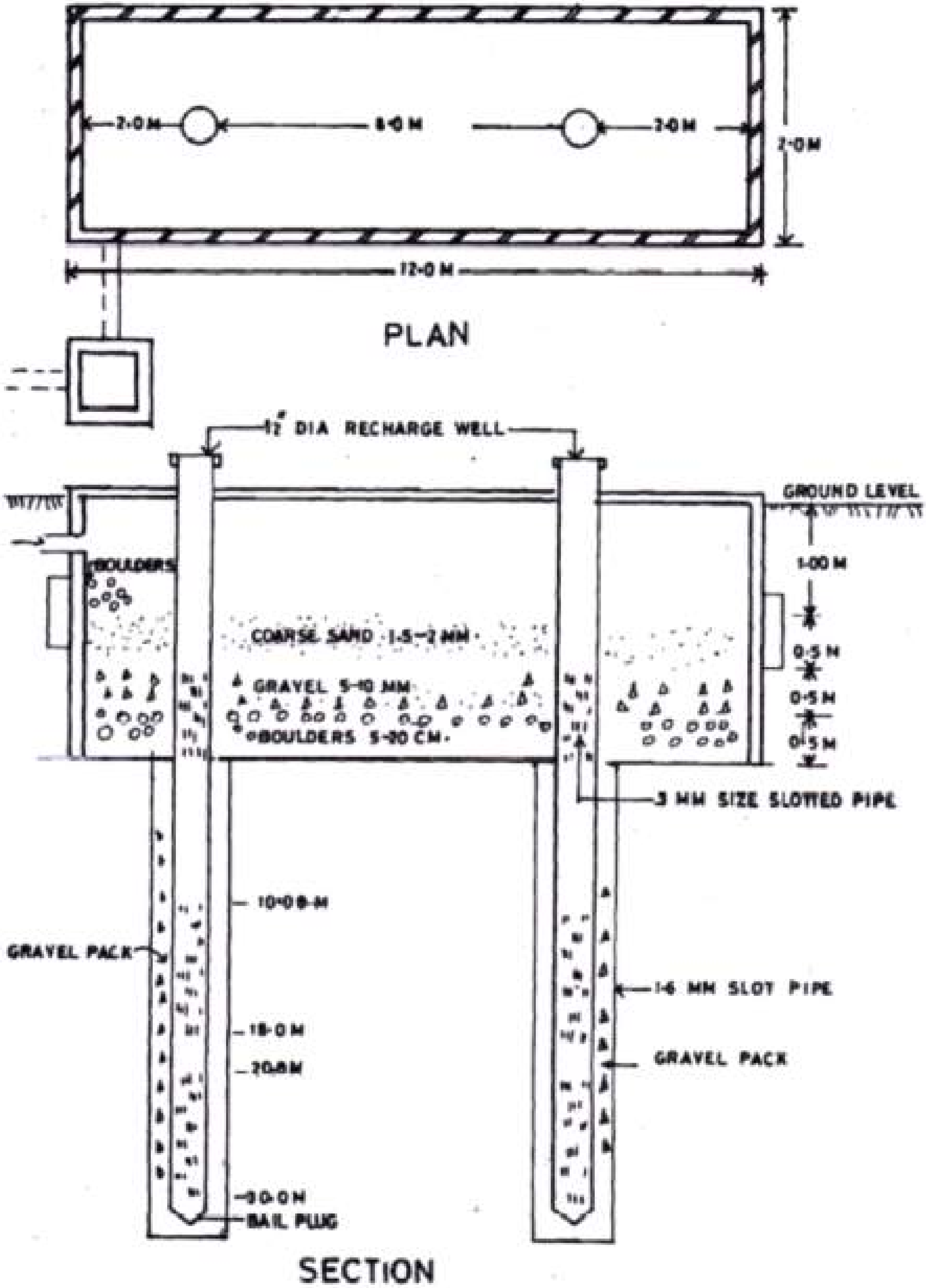
Drg. No. 28 Location of recharge structures at Sewa Bhawan R.K.Puram



Drg. No. 29 Design of recharge trench 1 (at Sewa Bhawan New Delhi)



Drg. No. 30 Design of lateral shaft 1, 2, 4, 5 & 6



Drg. No. 31 Design of lateral shaft 3 & 7

सत्यमेव जयते

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Central Public Works Department