STORM WATER MANAGEMENT, ARTIFICIAL RECHARGE & IMPROVEMENT IN GROUND WATER REGIME

By

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A water crisis is looming.

WATER SCENARIO

TODAY
AND
BEFORE

IN 2025

WATER SCENARIO

IN 2025

TODAY
AND
BEFORE

Today and before

IN 2025

Today and before

By 2025

Today and before

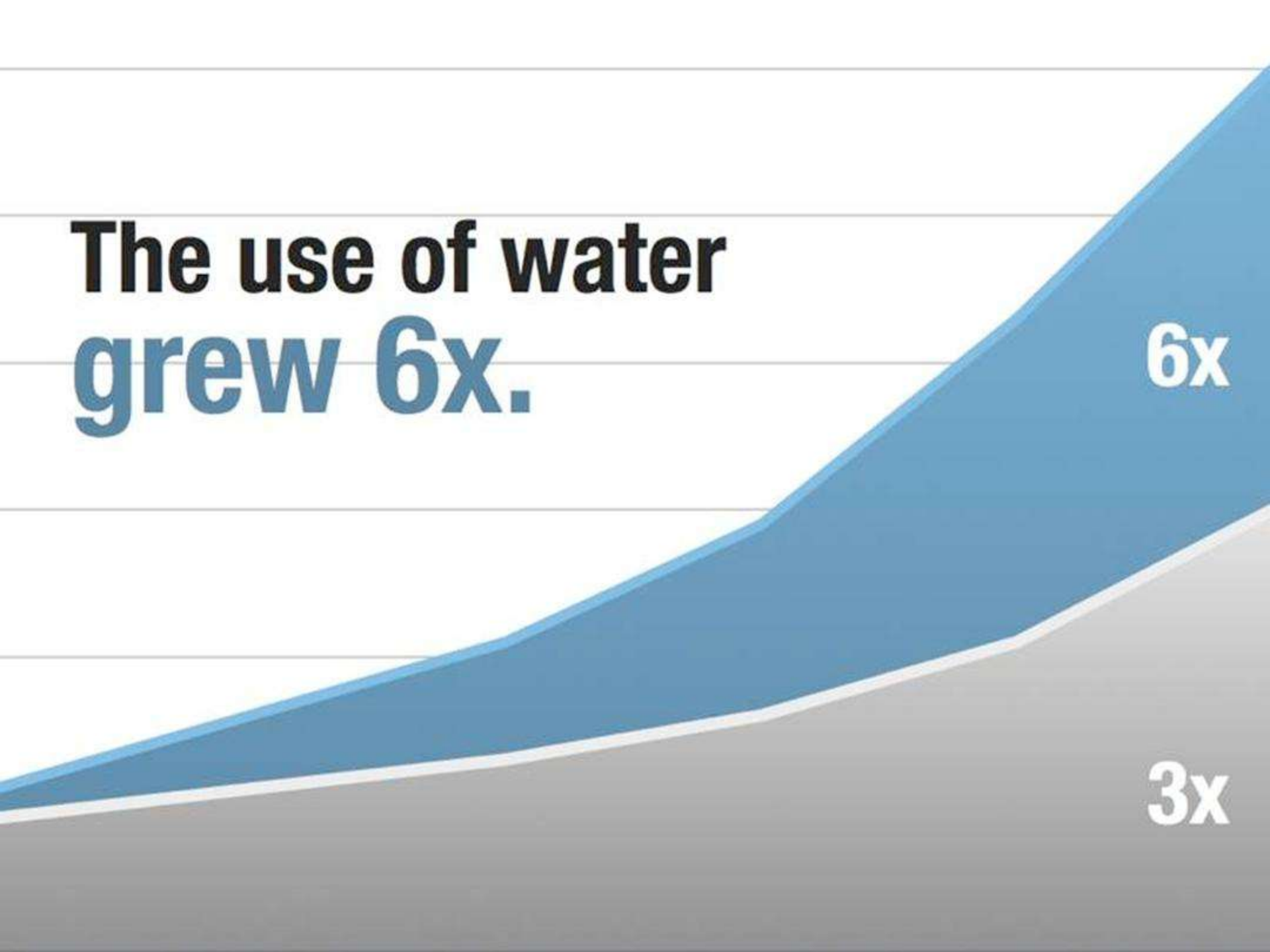
By 2025

Our water sources are under pressure.

In the 20th century
the world's population
tripled.

3x

The use of water grew 6x.

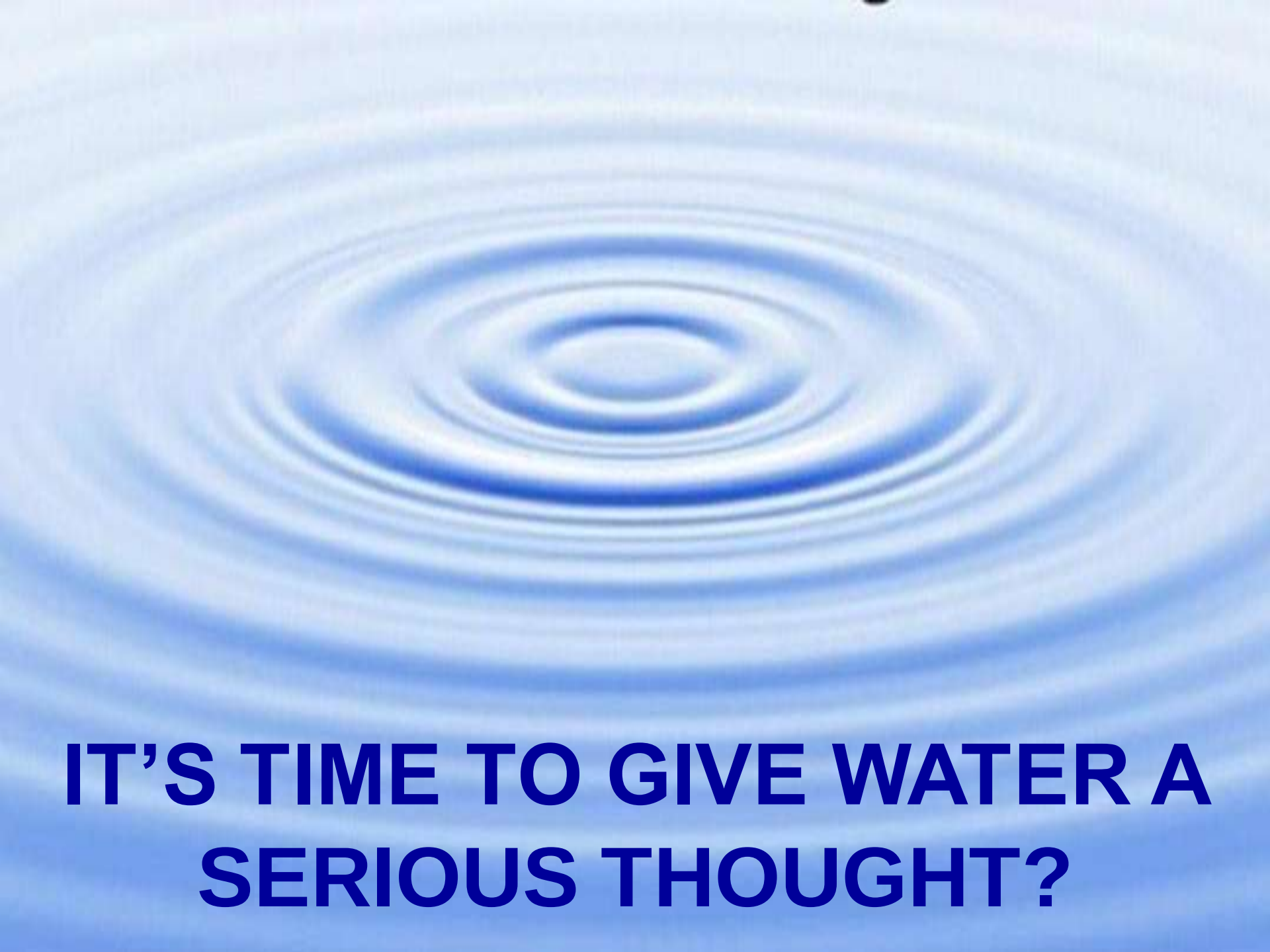


PRESENT WATER AVAILABILITY

1. India's population is 16% of the world population, whereas, water resources are only 4% that of the world.
2. Present water demand is 1122 billion m^3 (Surfce water690 billion m^3 and groundwater 432 billion m^3).
3. By 2010, groundwater demand would increase to 710 billion m^3.
4. By 2050, it would be 1180 billion m^3 i.e. less than availability.
5. In Rajasthan, total water availability is 10382 million m^3 at present, whereas the requirement is 12999 m^3.
6. Out of 236 blocks, 204 blocks are over-exploited due to above situation. The demand in 2025 would be doubled, we can imagine scenario of 2050.

FUTURE WATER SCENARIO

- Water availability will be to 1 person out of 3.
- Water quality will become unsafe in majority of the places.
- No food to 1/3 of the population.
- Many water borne diseases like Fluorosis, Dementia, Diarrhea, Cancer etc. will be order of the day.
- There will be fight for water between
  - Man to man.
  - City to city.
  - State to state.
  - Country to country
  - Possible third world war?


IT’S TIME TO GIVE WATER A SERIOUS THOUGHT?

STORM WATER MANAGEMENT AND RECHARGING GROUND WATER – ONE OF THE SOLUTIONS

- The storm water during rainy season causes drainage problem and often roads are damaged by rainfall runoff.
- This problem is serious in big cities and industries, where most of the open area is covered by roads or some concrete structures without proper drainage.
- The water on roads during rains remains stagnant for hours together due to poor storm water management and results into erosion of roads.
- In our country, industries and cities are facing water crises due to over exploitation of under ground water and no provision for recharge of aquifers.
- Declining water levels are also consuming more energy in lifting the water and reduction in green coverage.

STORM WATER MANAGEMENT AND RECHARGING GROUND WATER – ONE OF THE SOLUTIONS

- Solution of managing storm water on roads in urban and industrial areas is channilizing the same to ground water system in hygienic manner.
- This method not only helps in controlling the devastating effects of storm water, but would improve ground water regime both in terms of rising of water levels and increase in ground water availability.
- The techniques will also increase life of roads and reduce cost on maintenance and repairs. Besides, better plant growth is envisaged with less water requirement due to moist condition of surface soil through percolation structures.

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METHODOLOGY

- In designing rainwater-harvesting system, capturing rainfall run off from the roads and creating artificial connectivity to sub surface water in the hygienic manner is the key concept.

- The effectiveness of the concept lies in reasonable cost, coverage of large areas and immediate implementation and immense benefits in terms of additional water availability, improvement in water quality, increased plantation, maintaining eco-balance, reducing the cost on maintenance and repairs of roads and many fold increase in life of the roads.

METHODOLOGY

- Storm water harvesting along both the sides of roads with the help of suitable, simple structures, would not only control storm water hazards in cities, but will enhance ground water availability 8 to 10 times compared to natural process of rainfall infiltration.
- The location and design of sustainable storm water harvesting system require hydro geological study of the area as well as sub surface information of most permeable zone. Besides, average rainfall and rainfall intensity need to be analyzed as per climatic zones .
- Based on normal rainfall and peak rain fall intensity, the storm water harvesting system is designed in such a way that 70-80 % runoff of roads and paved area is sent back to ground water regime after natural filtration process based on Rate of Recharge after Recharge Test on existing wells/pits. .

RECHARGE TEST

The design is based on average annual rainfall and its intensity and the intake capacity of the water by the first aquifer.

In order to determine intake capacity of water by the aquifer, recharge test was carried out on an existing bore well/open well. In this test, water at varying rate was injected. For example- The water at rate of 500 liters/min did not spill over and the water column developed was recorded. The rate of dissemination of water column to the original static water level was periodically measured till original static water level was reached.

RECHARGE TEST DATA

Static water level = 6.20
Vol. of water injected = 500 liters (in 3 min.)
Initial water column observed = 5.21 m
Diameter of Well = 6 inches
Depth of well = 30 m
Total water dissemination period = 7 min.

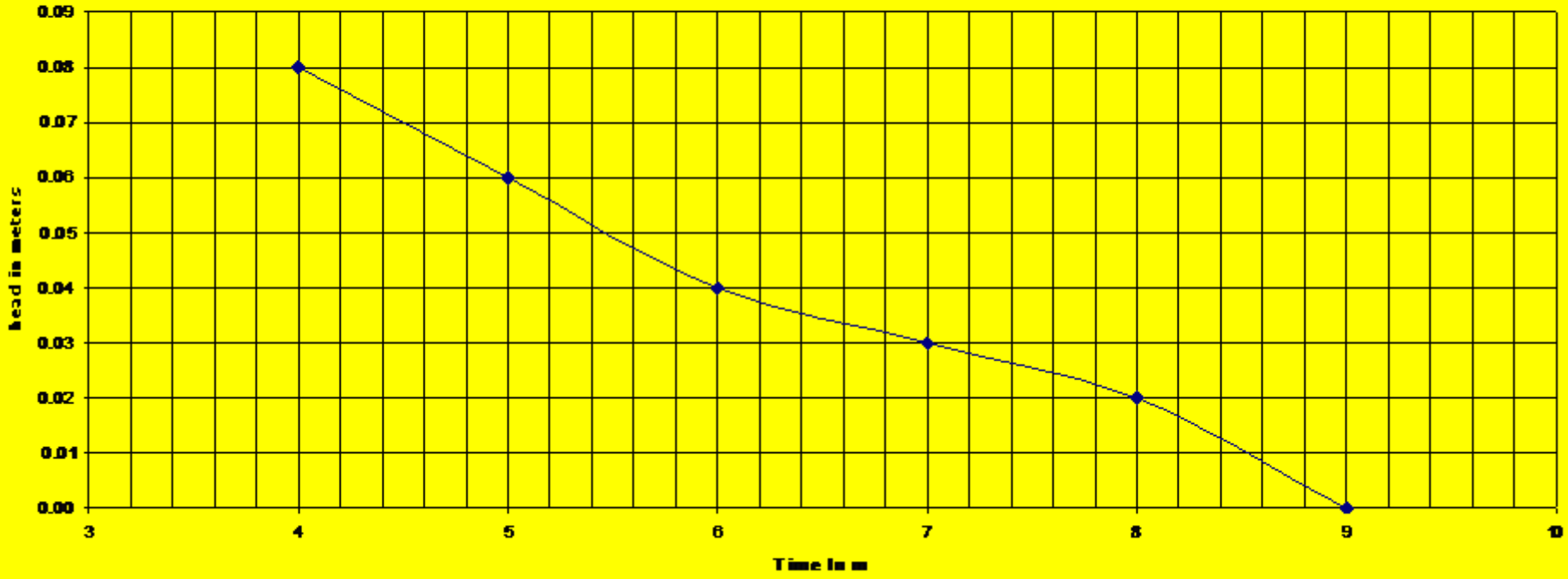
Time in min. (t)	Water level in meters (h)	Head in meters
4	6.12	0.08
5	6.14	0.06
6	6.16	0.04
7	6.17	0.03
8	6.18	0.02
9	6.20	0.00

Therefore, rate of water intake works out to be **0.055 m^3/min.** i.e. **3.3 m^3/hour**.

Hence,

Recharge capacity = 3.3 m^3/hour ≈ 79.20 m^3/day

Fig. 1: Recharge Test
Time V/S Head Plot



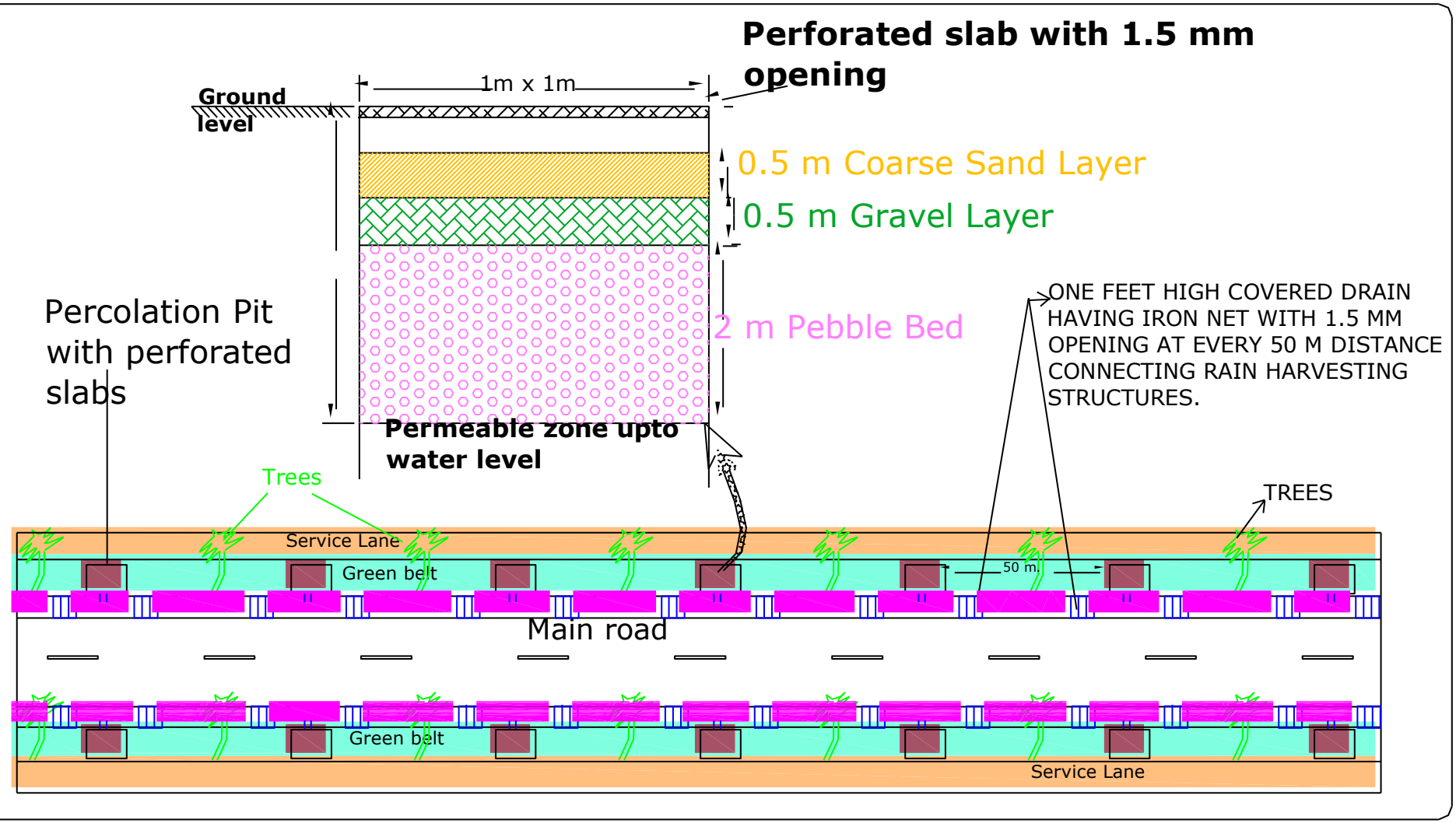
Therefore, the individual design can be made for accumulation of 79 m^3 of water & hence the dimensional parameter of each structure is kept as 5 m (length) x 5 m (width) x 3.25 m (depth) with 8”dia injection well/recharge shaft.

These structures may be made at proper spacing depending upon radius of influence.

DESIGN-I

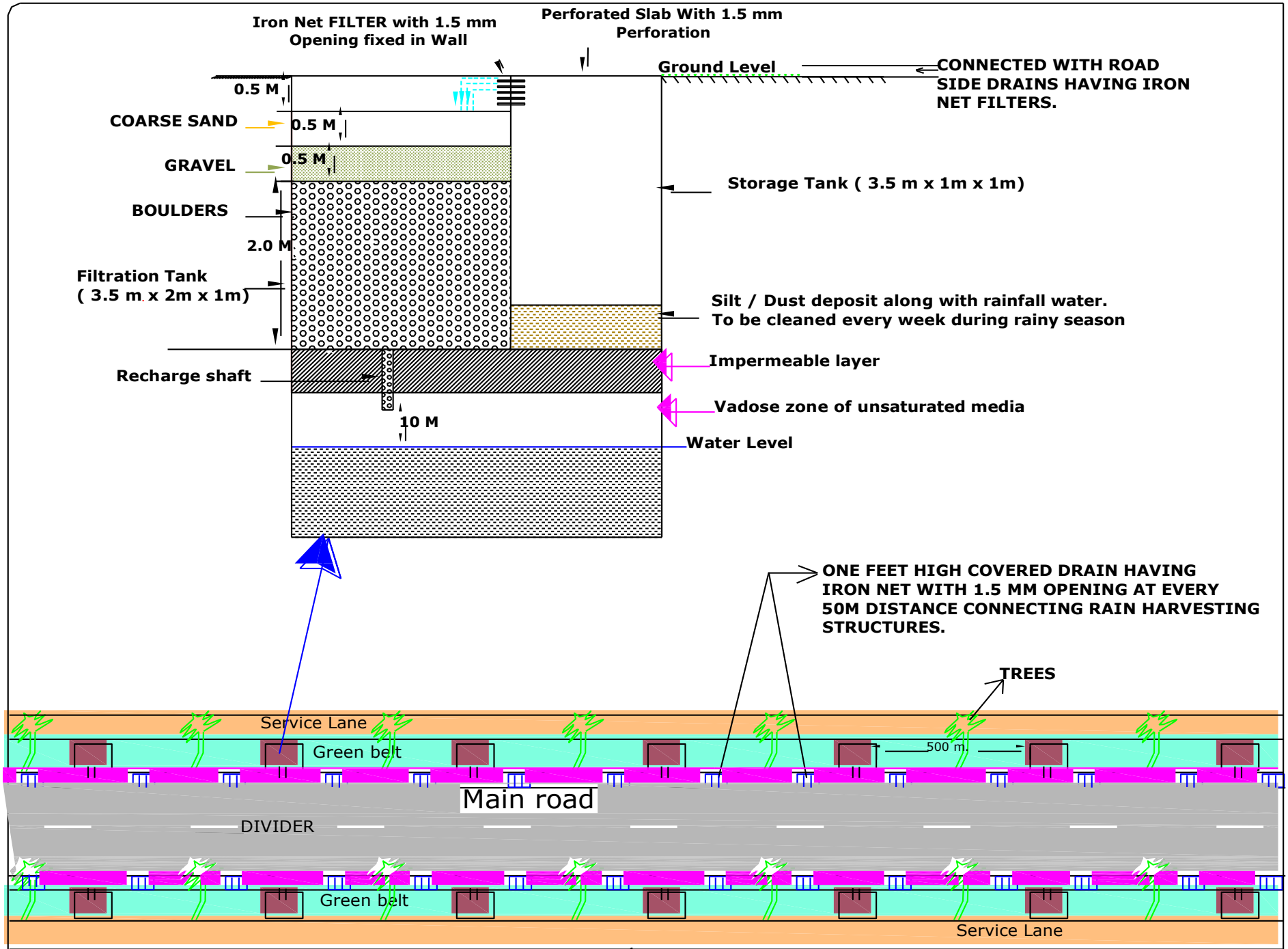
The area with soil/weathered rock having vertical permeability up to water level zone:

In this kind of situation, the percolation pit method would be suitable. In this method, the pits of suitable dimensions can be made along the roads between side lanes and main road. These pits may be made along both sides of the road at suitable interval based on estimated runoff. The pits should have natural filtration media of coarse sand, gravels and pebbles and should be covered with perforated slabs. The road should have 1 degree slopes towards these pits from the divider.


Perforated slab with 1.5 mm opening
1m x 1m
Ground level
0.5 m Coarse Sand Layer
0.5 m Gravel Layer
2 m Pebble Bed
Percolation Pit with perforated slabs
Permeable zone upto water level
ONE FEET HIGH COVERED DRAIN HAVING IRON NET WITH 1.5 MM OPENING AT EVERY 50 M DISTANCE CONNECTING RAIN HARVESTING STRUCTURES.
Trees
TREES
Service Lane
Green belt
50 m
Main road
Green belt
Service Lane

DESIGN-II

The area having impermeable zones prior to water level, like clays, solid rocks etc and having relatively clean catchment: In this type of areas, the rainwater harvesting system will have recharge shaft via storage tanks and filtration tanks reaching 10 to 15 meters above water level. The design is self explanatory as per Fig. 3. Here, water is diverted to ground water reservoir through recharge shaft via filtration media crossing the impermeable zone.


Iron Net FILTER with 1.5 mm Opening fixed in Wall
Perforated Slab With 1.5 mm Perforation
Ground Level
CONNECTED WITH ROAD SIDE DRAINS HAVING IRON NET FILTERS.
0.5 M
COARSE SAND
0.5 M
GRAVEL
0.5 M
BOULDERS
2.0 M
Filtration Tank (3.5 m x 2m x 1m)
Storage Tank (3.5 m x 1m x 1m)
Silt / Dust deposit along with rainfall water. To be cleaned every week during rainy season
Impermeable layer
Recharge shaft
Vadose zone of unsaturated media
10 M
Water Level
ONE FEET HIGH COVERED DRAIN HAVING IRON NET WITH 1.5 MM OPENING AT EVERY 50M DISTANCE CONNECTING RAIN HARVESTING STRUCTURES.
TREES
Service Lane
Green belt
500 m.
Main road
DIVIDER
Green belt
Service Lane

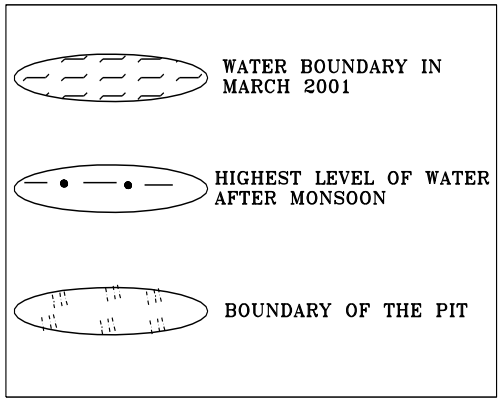
FORMER PRESIDENT OF INDIA IS DISCUSSING WITH DR.JAIN ABOUT VIABILITY OF ROADSIDE RAINWATER HARVESTING ALONG HIGHWAYS

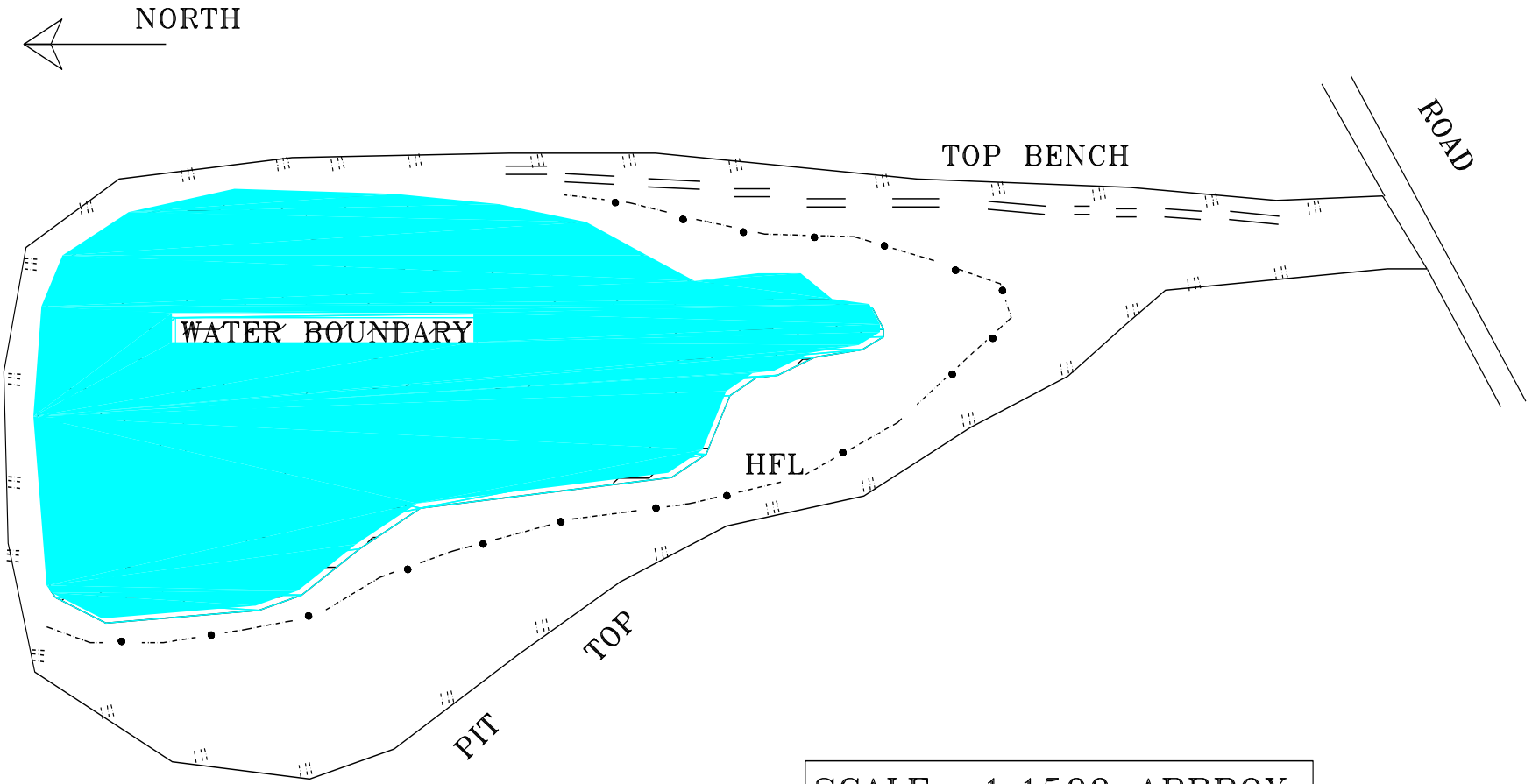
DESIGN-III - Artificial Recharge reservoir

The storm water generated in cities & industries with large catchment can be diverted to scientifically designed artificial reservoir based on runoff generated at peak rainfall intensity and recharge potential of sub-surface strata. In case of higher infiltration capacity of vadose & unsaturated zone, percolation pits with recharge shaft are planned for increased recharge from surface water storage.

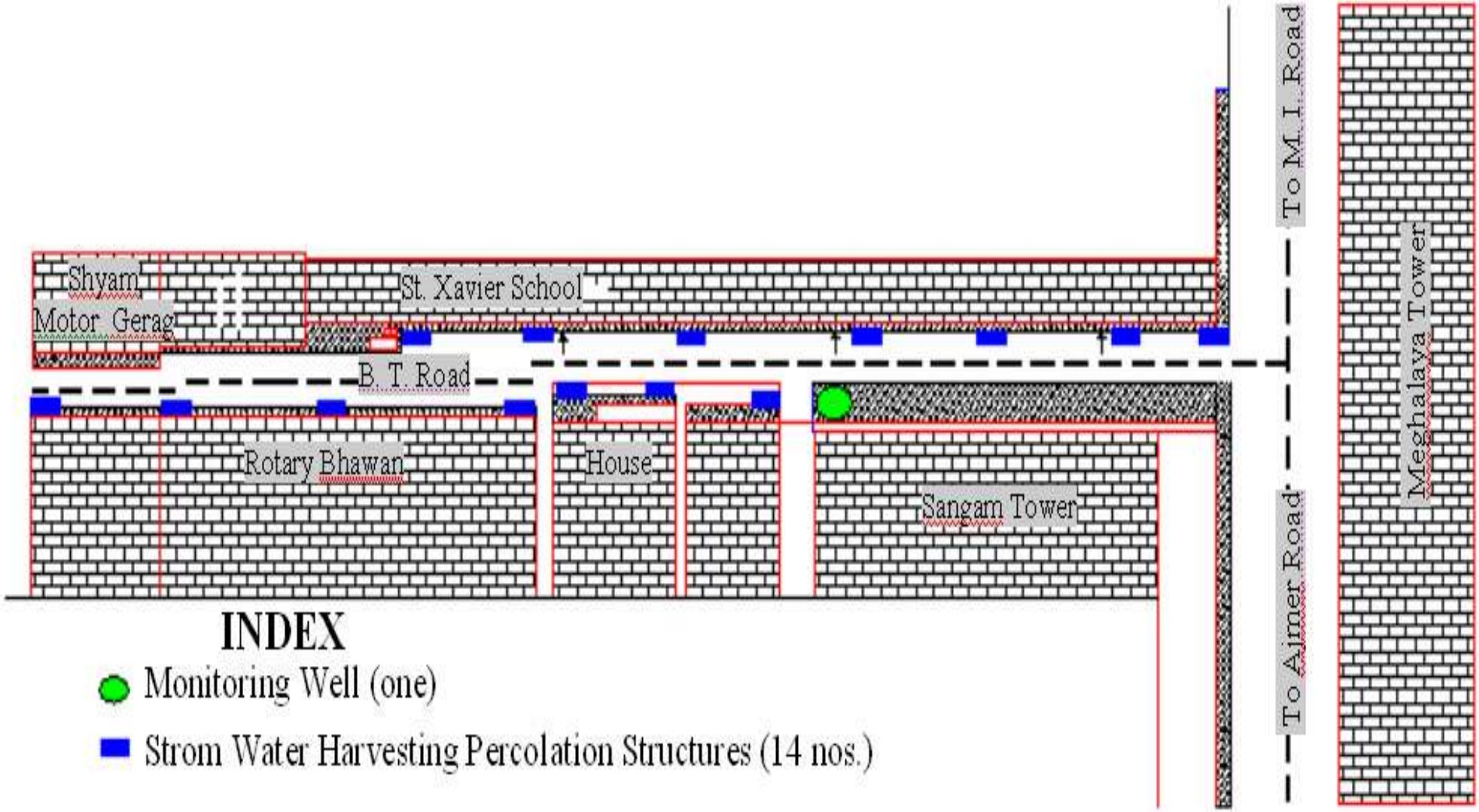
DYNAMICS OF WATER IN PIT:

1. LEVEL DIFFERENCE BETWEEN PIT TOP TO PRESENT WATER LEVEL = 6.94m
2. LEVEL DIFFERNCE BETWEEN WATER LEVEL AND HFL MARK = 3.64m
3. AVERAGE DEPTH OF WATER COLUMN = 3.0m (MARCH, 2001)
4. AREA OF WATER BOUNDARY = 9225m^2 (MARCH, 2001)
5. AREA OF HFL BOUNDARY= 12000m^2
6. AREA OF TOP SURFACE BOUNDARY = 18225m^2





Case Study-I: STORM WATER MANAGEMENT PROJECT ON ROTARY MARG, JAIPUR

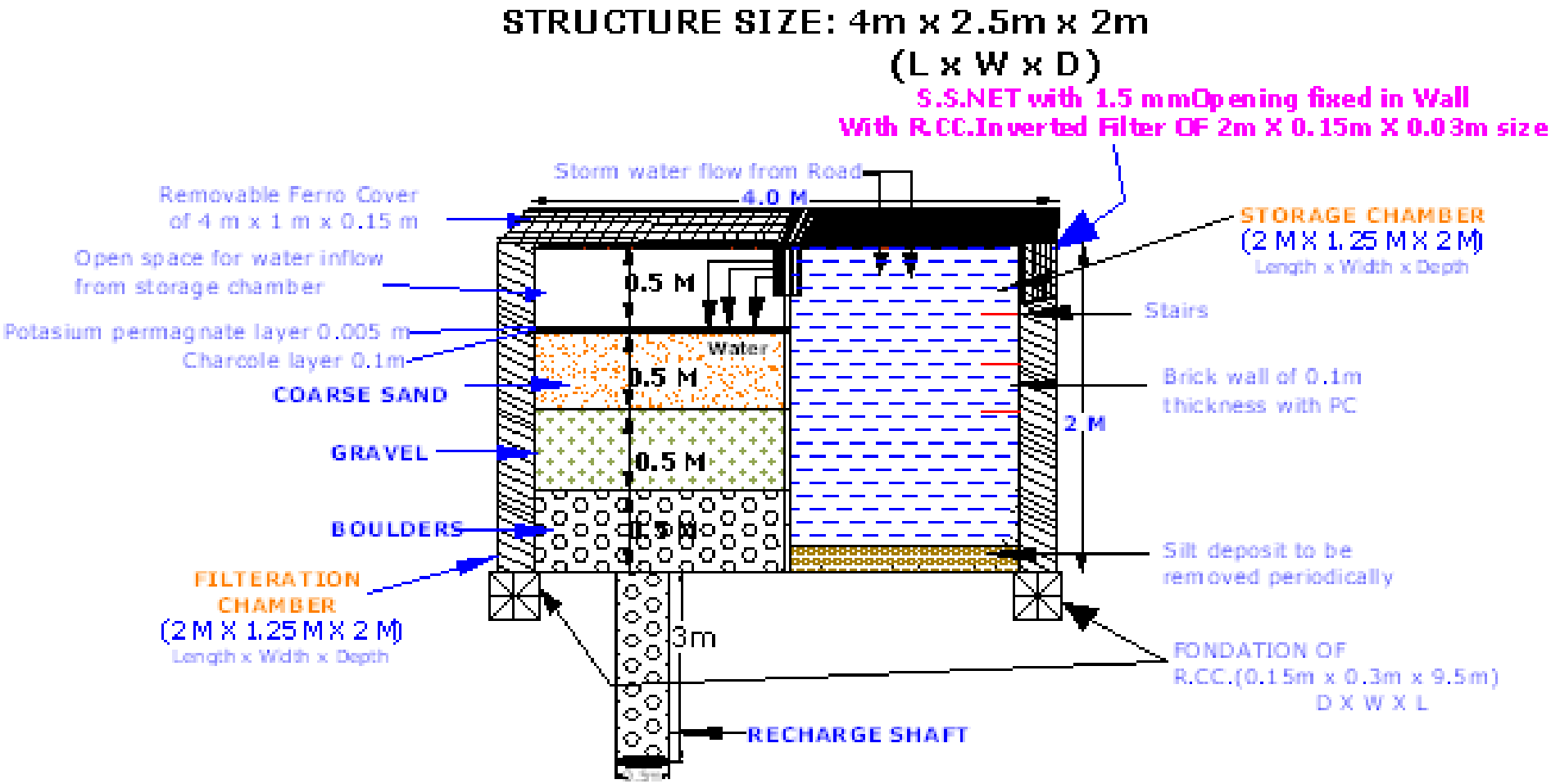


Analysis of Recharge test in Rotary Bhawan reveals that instantaneous dissemination of water is 0.47 m3 in 1 min = 0.5 m3 per minute. Based on aquifer water intake capacity determined through recharge test and estimation of road runoff of 15 min. peak rainfall, percolation structures were designed with optimum numbers.

The area with soil / weathered rock has vertical permeability up to water level zone without impermeable layer. In this kind of situation, the percolation structures of average 2 m depth, 4 m length and 1.5 m width has been made along both sides of Rotary Marg from Rotary Bhawan to Sangam Tower. Such 14 structures on both the sides of the road have been made to recharge most of runoff generated in a single storm. The percolation structures have natural filtration media of coarse sand, gravels and pebbles with charcoal layer of 0.1 m followed by 0.005 m layer of potassium permanganate and covered with removable slabs. The road was requested to be made with 1 degree slope towards these structures from the center with the help of Jaipur Municipal Corporation.

PERCOLATION STRUCTURE

SCHEMATIC DIAGRAM FOR DESIGN OF ROAD STORM WATER HARVESTING STRUCTURE



The length of the road is about 400 m with average width of 8 m. Considering 600 mm annual rainfall and road catchment factor 0.75, direct runoff on road would be 1440 m3/ annum. Rotary marg also receives runoff from the roofs of adjoining houses and Hathroi hillock. The additional catchment area works out to be nearly 4000 m2. The additional runoff will be 1800 m3/ annum.

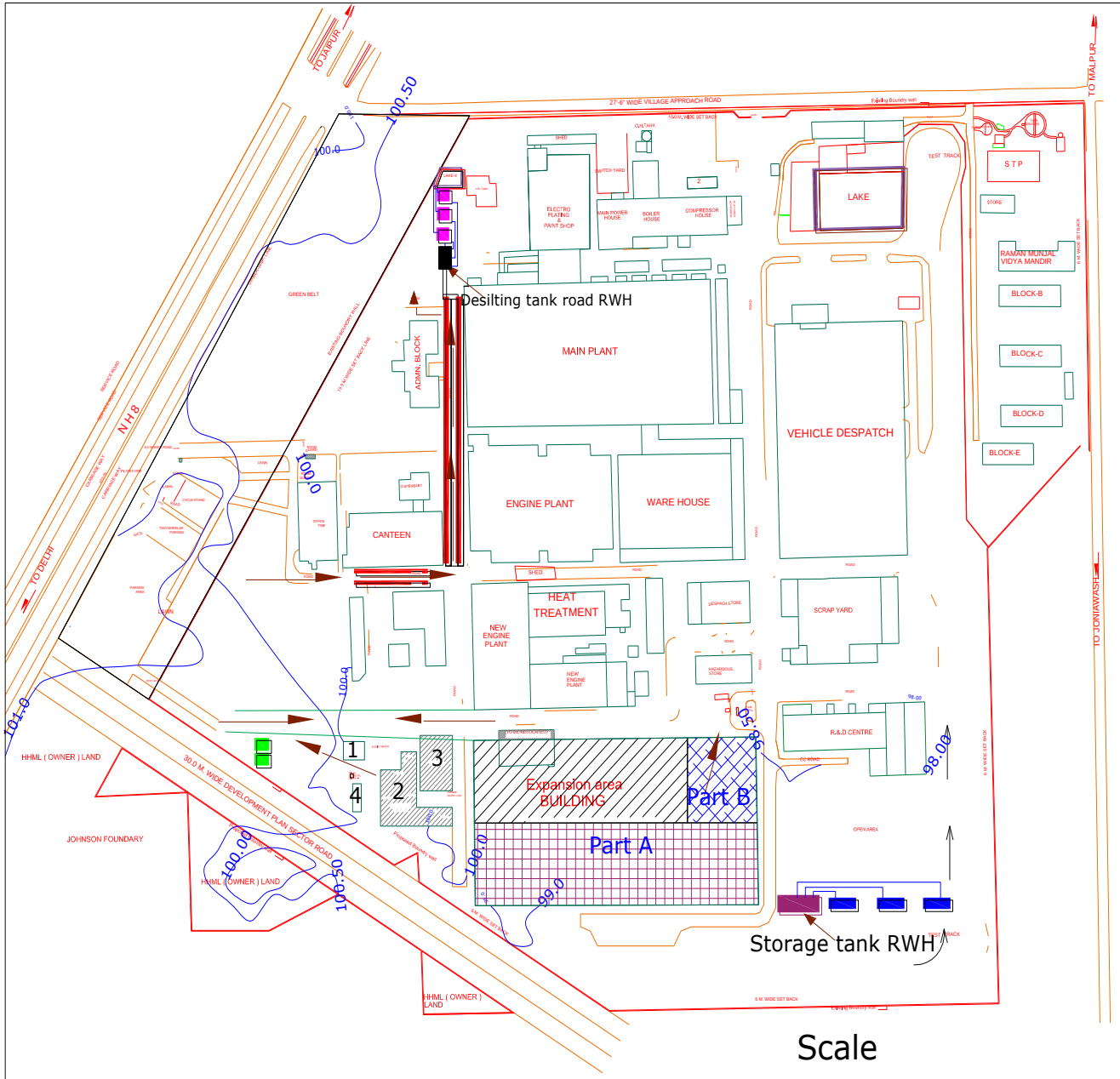
The total runoff available for recharge will be around 3000 m3 / annum. Considering 60 mm as peak rainfall for Jaipur region, single storm of 15 minutes is expected to generate runoff on road of the order of 80 m3. Each structure will have 6 m3 of water in the system at any point of time with recharge rate of 0.5 m3 / min. 14 structures designed would be able to accommodate 80 m3 of runoff during any single storm. Hence, systems designed would be functional efficiently in long term.

HER EXELLENCY, THE THEN GOVENOR OF RAJASTHAN AND NOW PRESIDENT OF INDIA IS DISCUSSING URBAN STORM WATER RECHARGE PROJECT WITH Dr. S.K.JAIN

CASE STUDY – II

Road/paved area storm water recharge in industrial premises of Hero Honda Motors Limited, Dharuhera, Haryana

The total area of the roads of the factory premises is **7581.5 m^2**, which would generate **85.29 m^3** volume of storm water runoff for recharge to the ground water at an average rainfall of **726 mm**, considering peak rainfall intensity of 60 mm/hour and 0.75 as the catchment factor.



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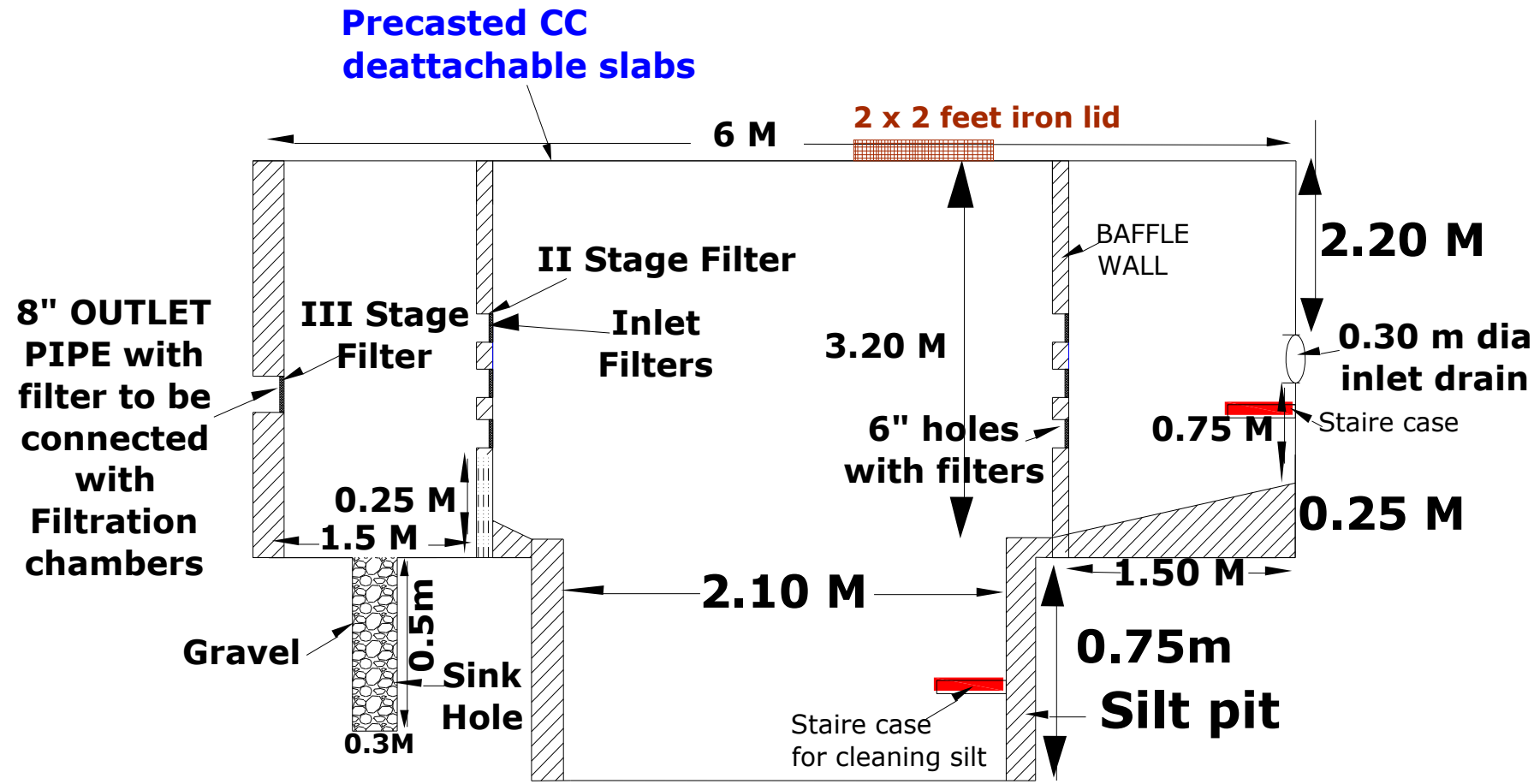
Building	RWH structures
Rooftop rainwater harvesting structures for extension building with one storage tank	(3 structures) (Phase I)
Road storm water harvesting with desilting tank (Admin Block)	(3 structures)
Road storm water harvesting desilting tank (Tool room)	(2 structures)
Drains along road	(0.3m. x 0.3m.) (Width X Depth)
Existing roads	
Old Buildings	
Lawn/open ground	
Existing Lake	
Proposed extension plant building	
Runoff flow direction	
Connecting 8" pipes from Desilting/Storage Tank to Filtration Chambers	

Scale

0 1 2 3 4 (In.cm.)

0 44 88 132 176 (In.m.)

SCHEMATIC DIAGRAM FOR DESIGN OF DESILTING TANK NEAR ADMIN BLOCK AND TOOL ROOM AT HERO HONDA MOTORS LTD., DARUHERA



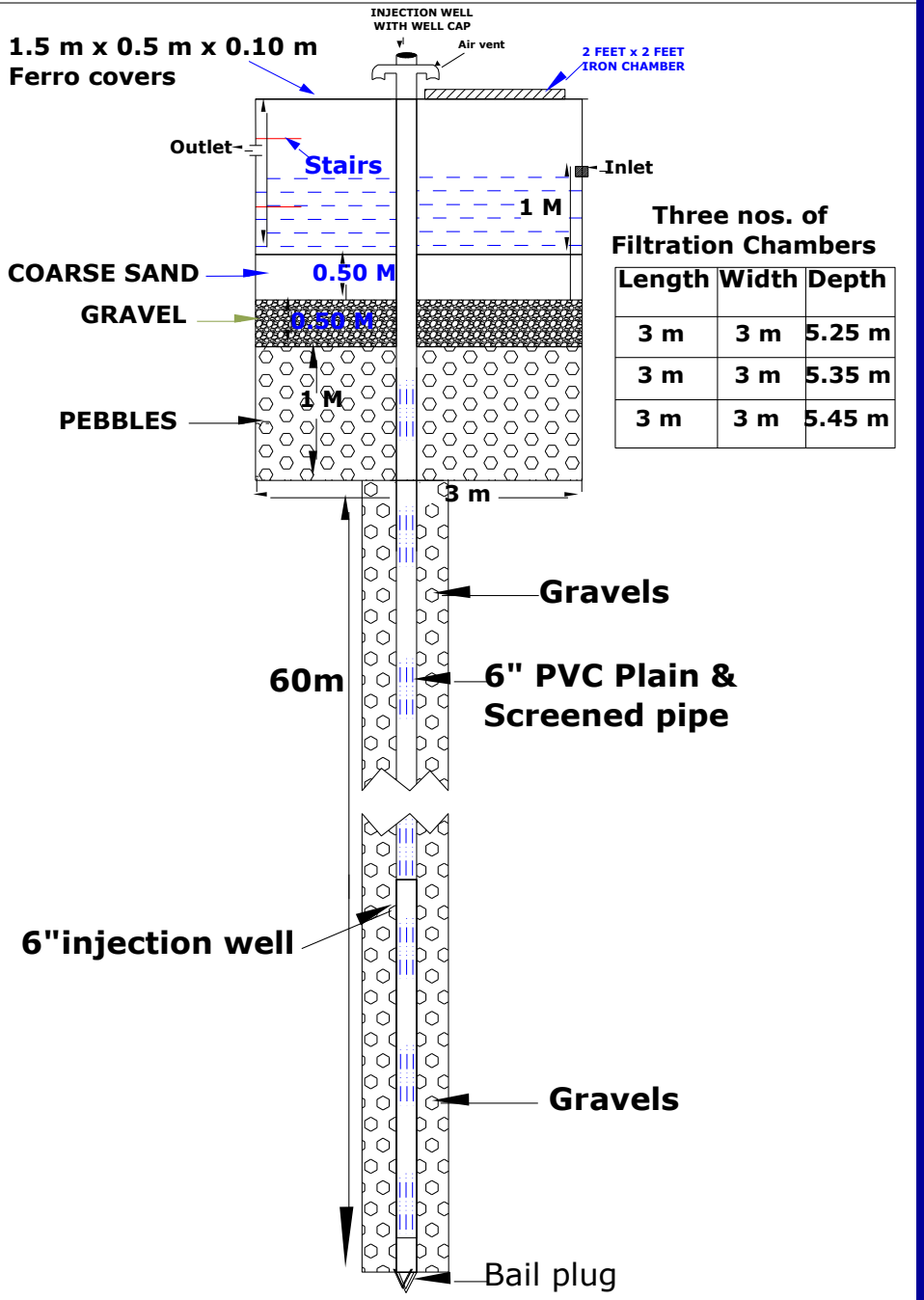
Desilting Tank

(6 m x 3 m x 3.20/3.95 m*)

(length*width*depth)

***- WOULD VARY AS PER INVERTED LEVEL OF INLET DRAIN**

SCHEMATIC DIAGRAM FOR DESIGN OF PROPOSED FILTRATION CHAMBERS NEAR ADMIN BLOCK AT HERO HONDA MOTORS LTD., DARUHERA



Three nos. of Filtration Chambers

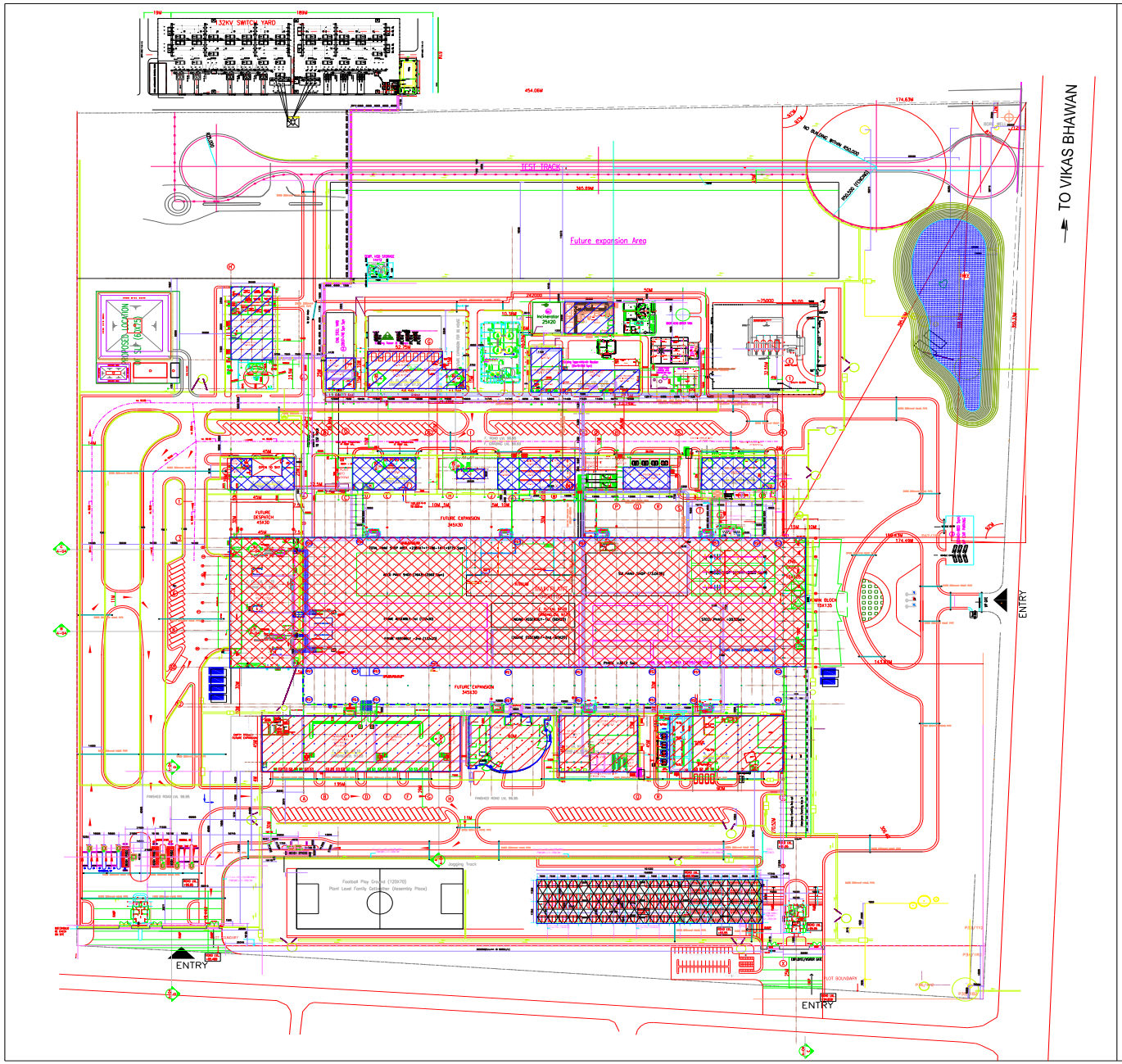
Length	Width	Depth
3 m	3 m	5.25 m
3 m	3 m	5.35 m
3 m	3 m	5.45 m

CASE STUDY – III

Road/paved area storm water recharge through artificial recharge reservoir in industrial premises of Hero Honda Motors Limited, Haridwar, Uttranchal.

The total area of the roads and paved areas of the factory premises is **115080 m^2**, which would generate **129465 m^3** volume of storm water runoff for recharge to the ground water at average rainfall of **1520 mm** per annum**.** The storm water drains as shown meets reservoir at the inlets (I1 and I2). For extreme events of rainfall, two spillways are designed for overflow of water towards main road as shown in **Fig. 13**. To prevent sand, two desilting tanks are recommended at the inlets to the reservoirs.

Map showing the locations of Roof top Rainwater Harvesting structures and Storm water reservoir in the plant premises of Hero Honda Motors Ltd., Haridwar



NORTH

W E

S

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Investigated Site boundary

Drain

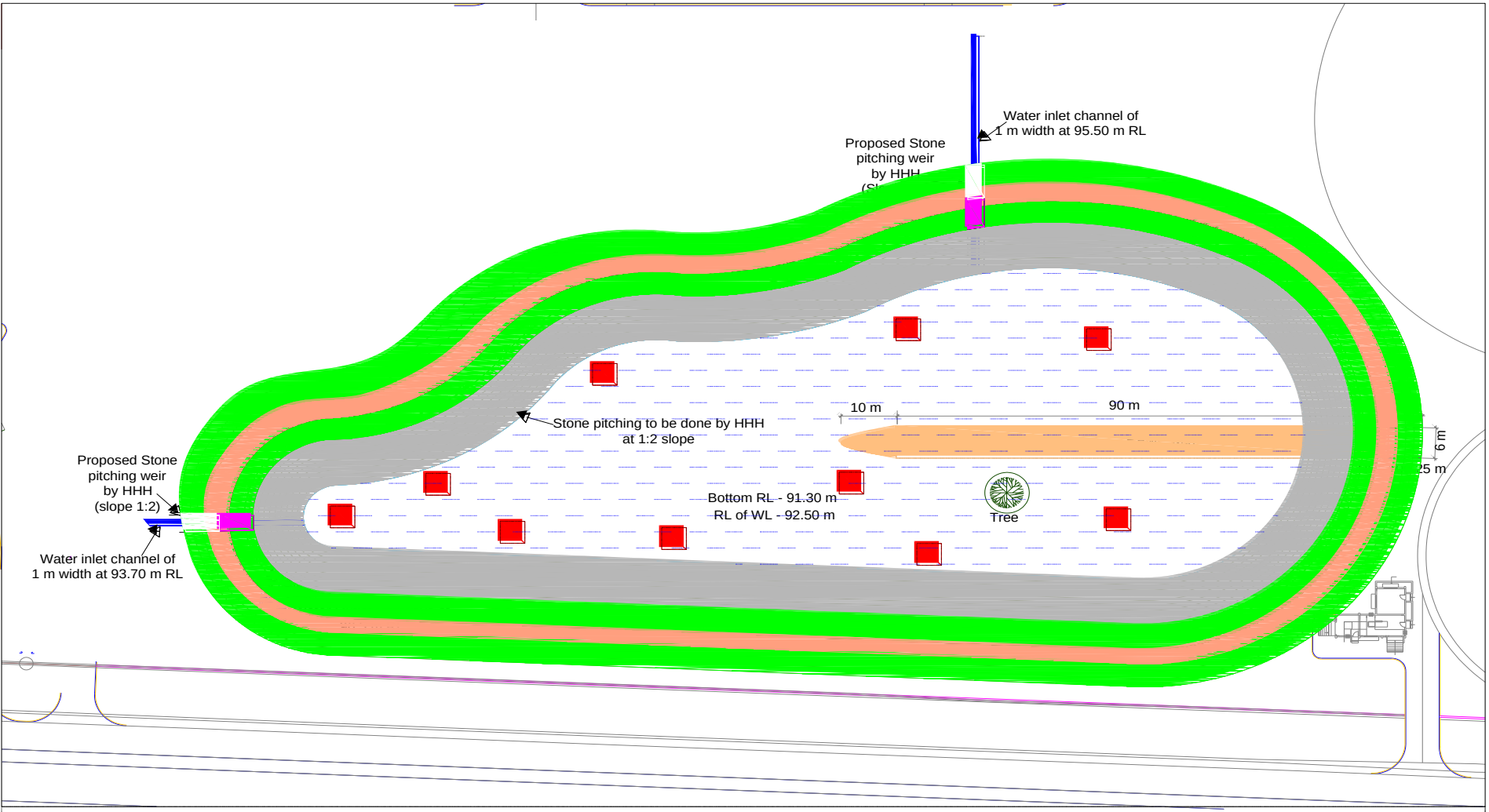
RWH Recharge Reservoir with ten percolation structures

Building	RWH structures
B-1 buildings	(6 Structures)
B-2 buildings	(1 Structure)
B-4 buildings	(1 Structure)

Scale

0 1 2 3 (In cm)

0 44 88 132 (In mt.)



RWH Reservoir boundary

Ramp/Maintainance Track

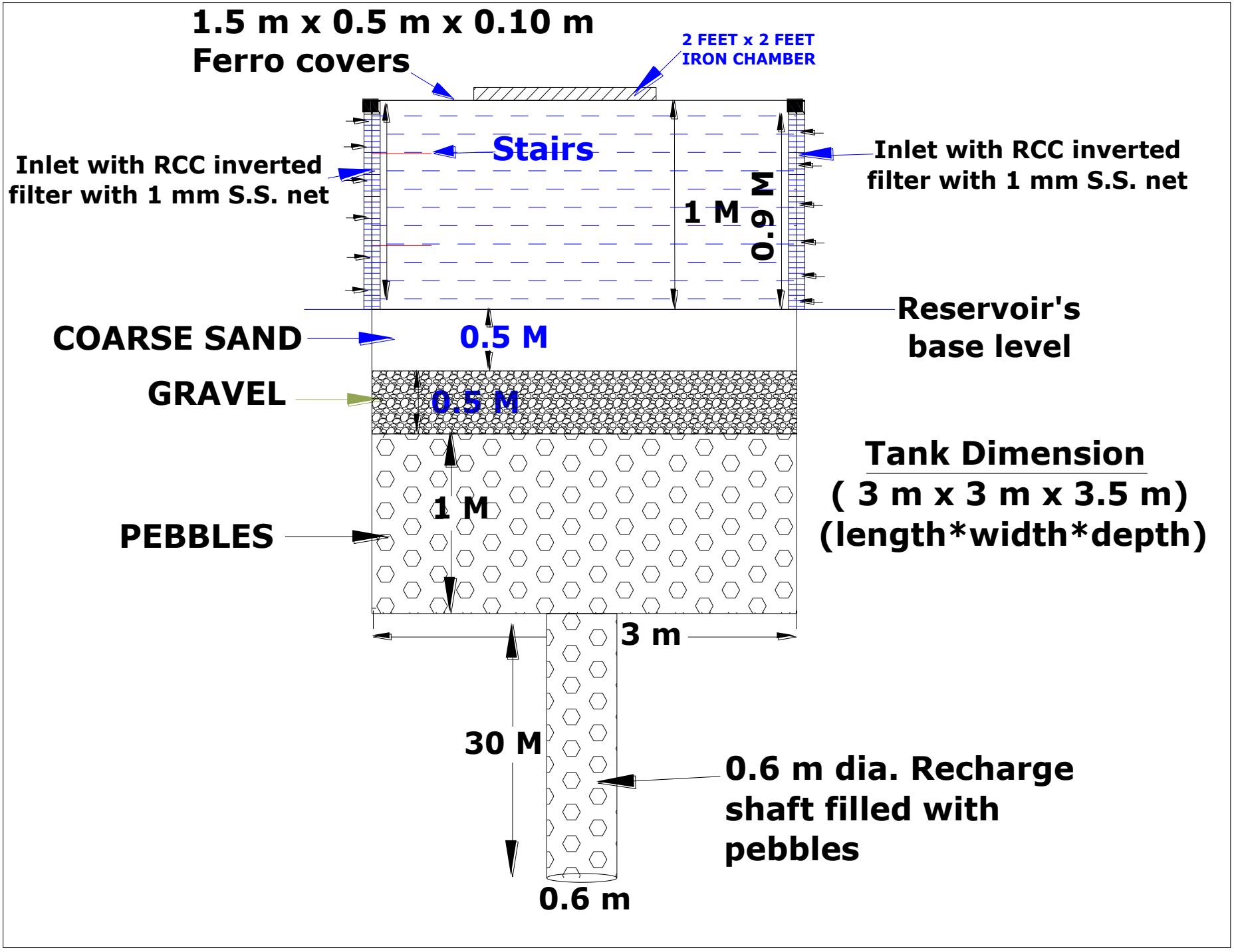
Bunding
(2.4 m height, 12 m width with 6 m flat top)

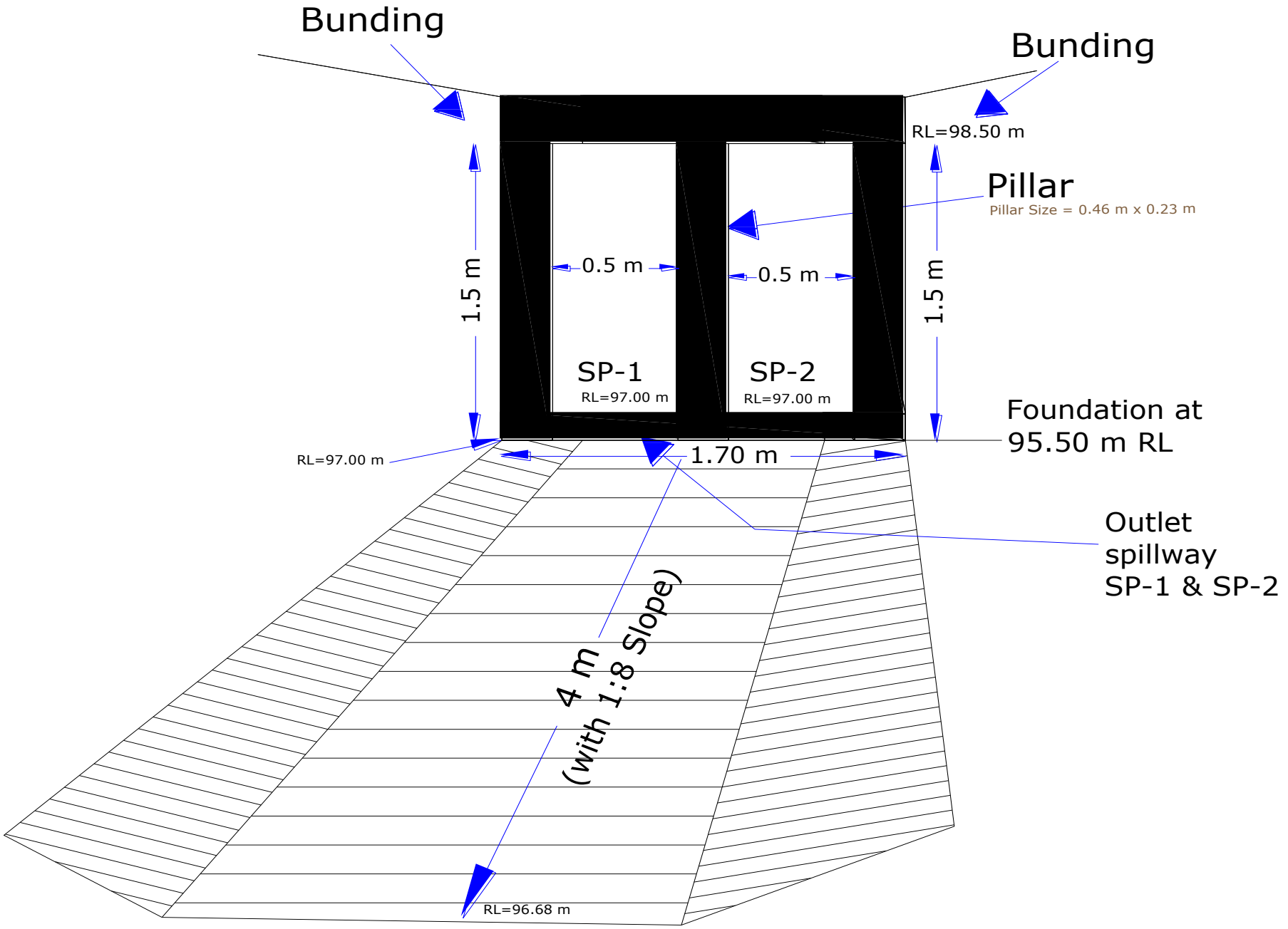
Water Inlet Channel

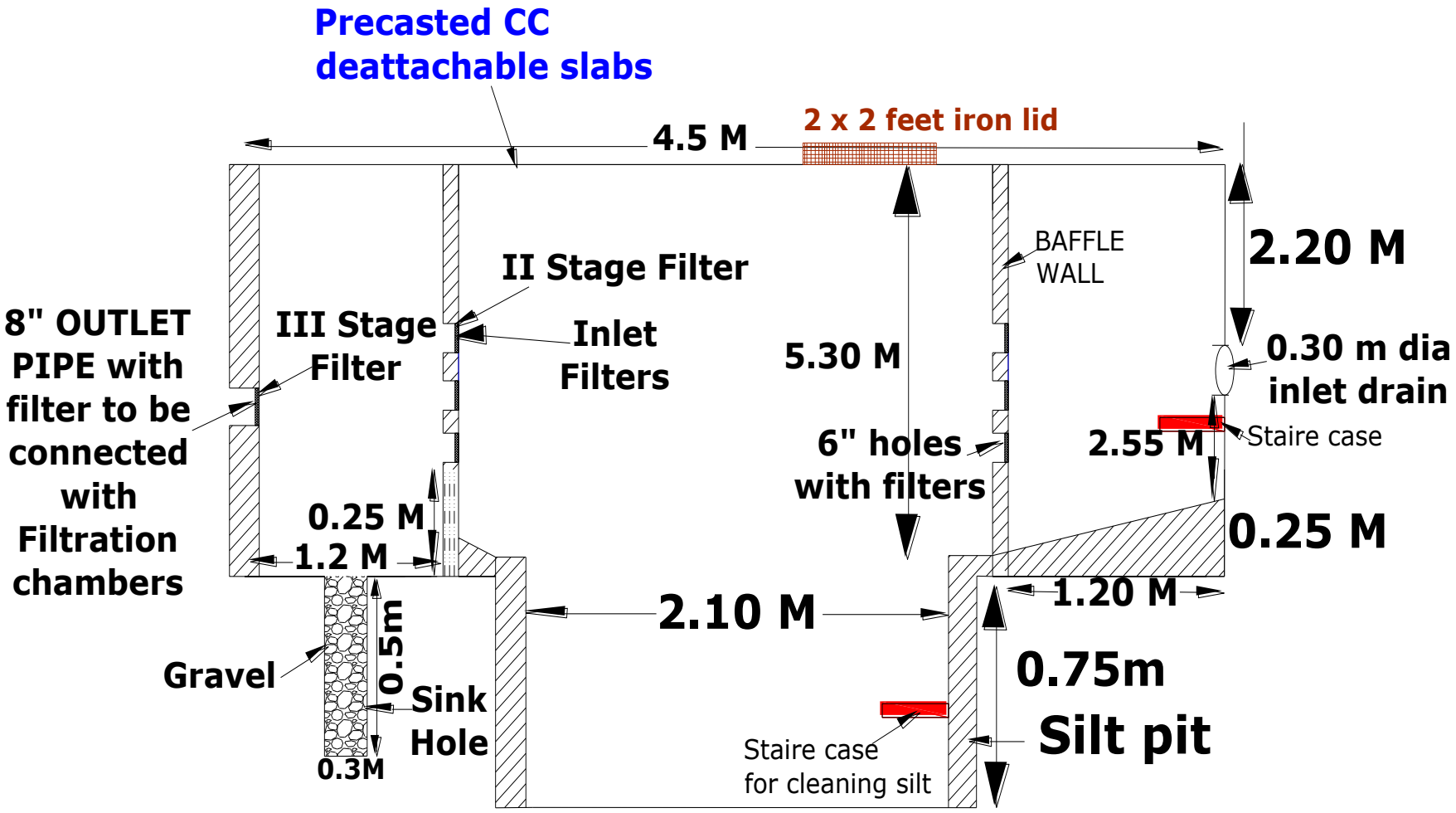
Percolation Structures

Water outlet Spillway

Desilting Tank


1.5 m x 0.5 m x 0.10 m
Ferro covers
2 FEET x 2 FEET
IRON CHAMBER
Stairs
Inlet with RCC inverted filter with 1 mm S.S. net
Inlet with RCC inverted filter with 1 mm S.S. net
1 M
0.9 M
Reservoir's base level
COARSE SAND
0.5 M
GRAVEL
0.5 M
1 M
PEBBLES
Tank Dimension
(3 m x 3 m x 3.5 m)
(length*width*depth)
3 m
30 M
0.6 m dia. Recharge shaft filled with pebbles
0.6 m

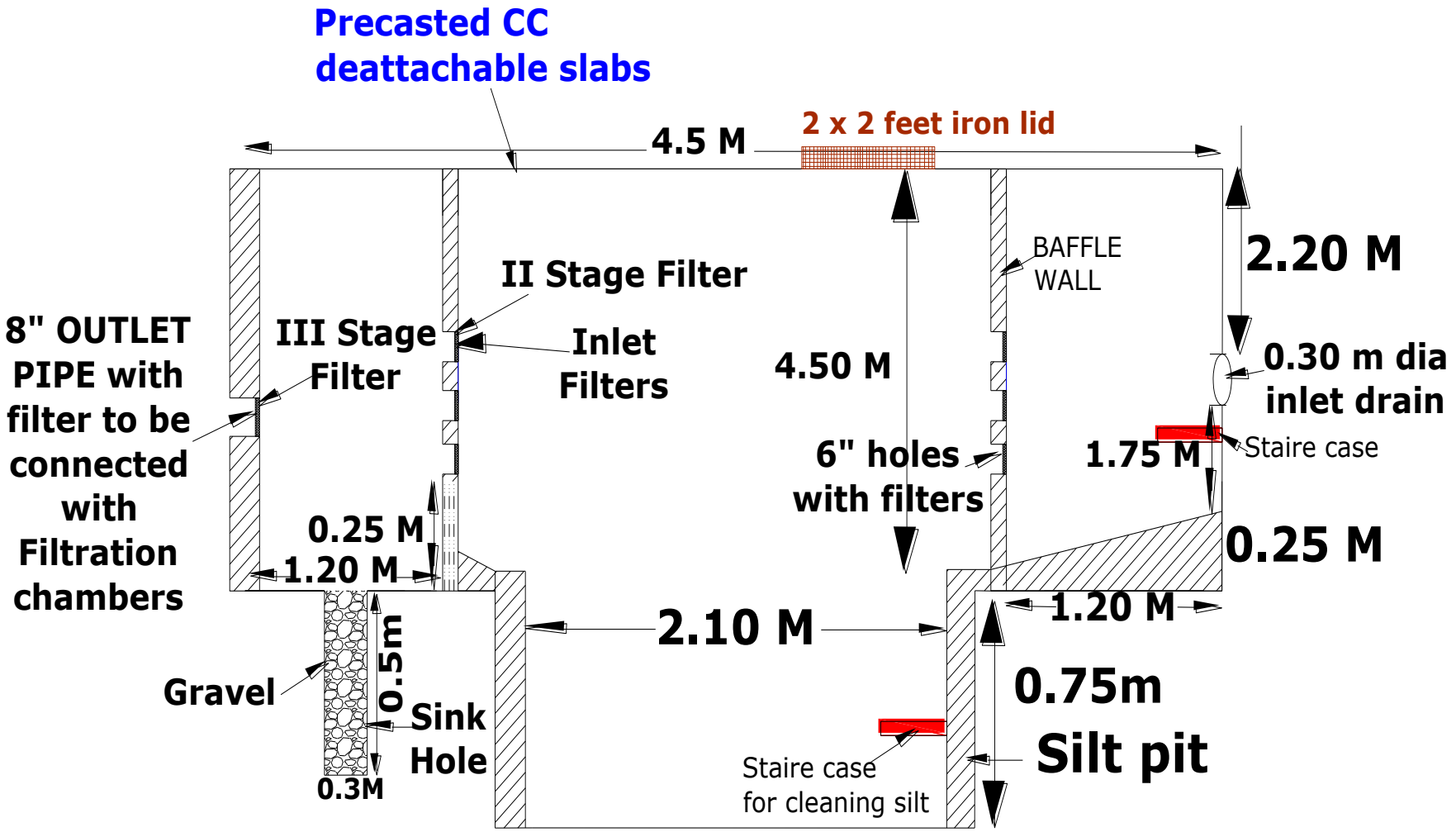

Bunding
Bunding
RL=98.50 m
Pillar
Pillar Size = 0.46 m x 0.23 m
1.5 m
0.5 m
0.5 m
1.5 m
SP-1
RL=97.00 m
SP-2
RL=97.00 m
Foundation at
95.50 m RL
RL=97.00 m
1.70 m
Outlet
spillway
SP-1 & SP-2
4 m
(with 1:8 Slope)
RL=96.68 m



Desilting Tank

(4.5 m x 4 m x 5.30/6.05 m)

(length*width*depth)



Desilting Tank

(4.5 m x 4 m x 4.50/5.25 m)

(length*width*depth)

*

REMOVAL OF POLLUTANTS

The percolation structures are designed with sufficient vedose zone acting as natural filter that removes pollutants and other impurities from the water as it moves down to the ground water through natural filtration media consisting of pebbles, gravels, coarse sand, charcoal and potassium permanganate layers .

QUALITY IMPROVEMENT

Quality improvement through proper infiltration management is achieved as follows: (Herman Bouwer, USA)

1. Suspended Solids: essentially complete removal
2. Dissolved Solids: No removal
3. Biodegradable organic compounds (BOD): Essentially complete removal
4. Synthetic organic compounds : Some are almost completely removed, some significantly and some very little.

QUALITY IMPROVEMENT ….

5. Bacteria and viruses: Essentially complete removal
6. Nitrogen : Significant removal .
7. Phosphorus : Significant removal .
8. Fluoride: Significant removal
9. Heavy metals : Significant to essential removal
10. Boron : No removal.

MONITORING OF IMPROVEMENT OF GROUND WATER REGIME IN PROJECT AREA

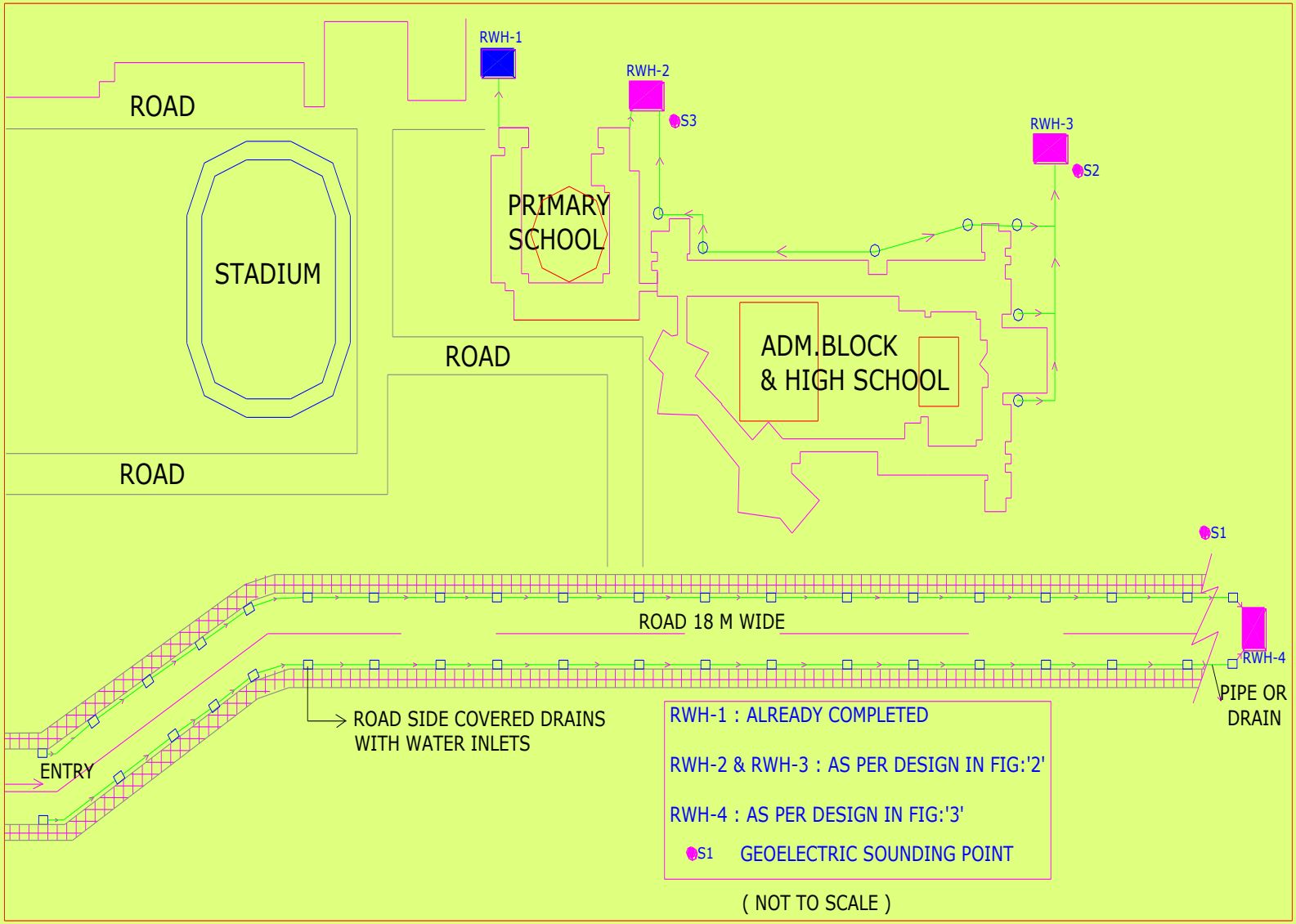
1. Monitoring well should be installed near Project area for continuous record of water level and quality.
2. Water quality and water level at this station should be monitored four times in a year for long term assessment of impact of the project on ground water condition in the area.

BENEFITS OF STORM WATER HARVESTING

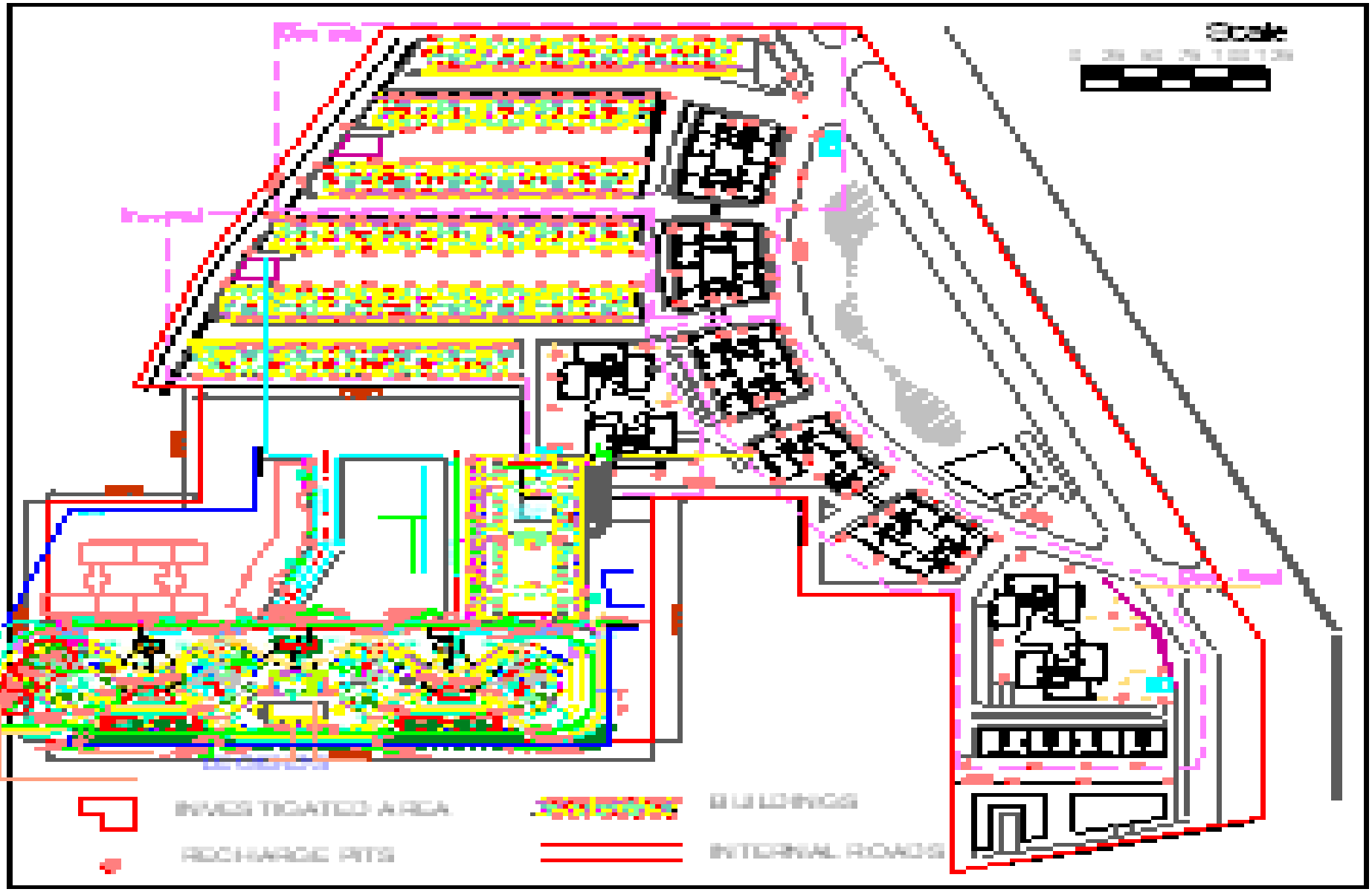
- **Reduction in runoff which chokes storm drains.**
- **No flooding of roads and increase in life of roads.**
- **Augmentation of ground water storage and control of decline of water levels.**
- **Improvement of quality of ground water.**
- **Reduction of soil erosion.**
- **Surviving water requirement during summer, drought etc. in cities and industrial areas.**
- **The method can also be applied on all highways for improving ground water regime and to increase life of roads.**

OTHER CASE STUDIES

RAINWATER HARVESTING STRUCTURES IN RUKMANI BIRLA EDUCATIONAL INSTITUTE.



Vatika City-Gurgaon



A very Big Thank you to all