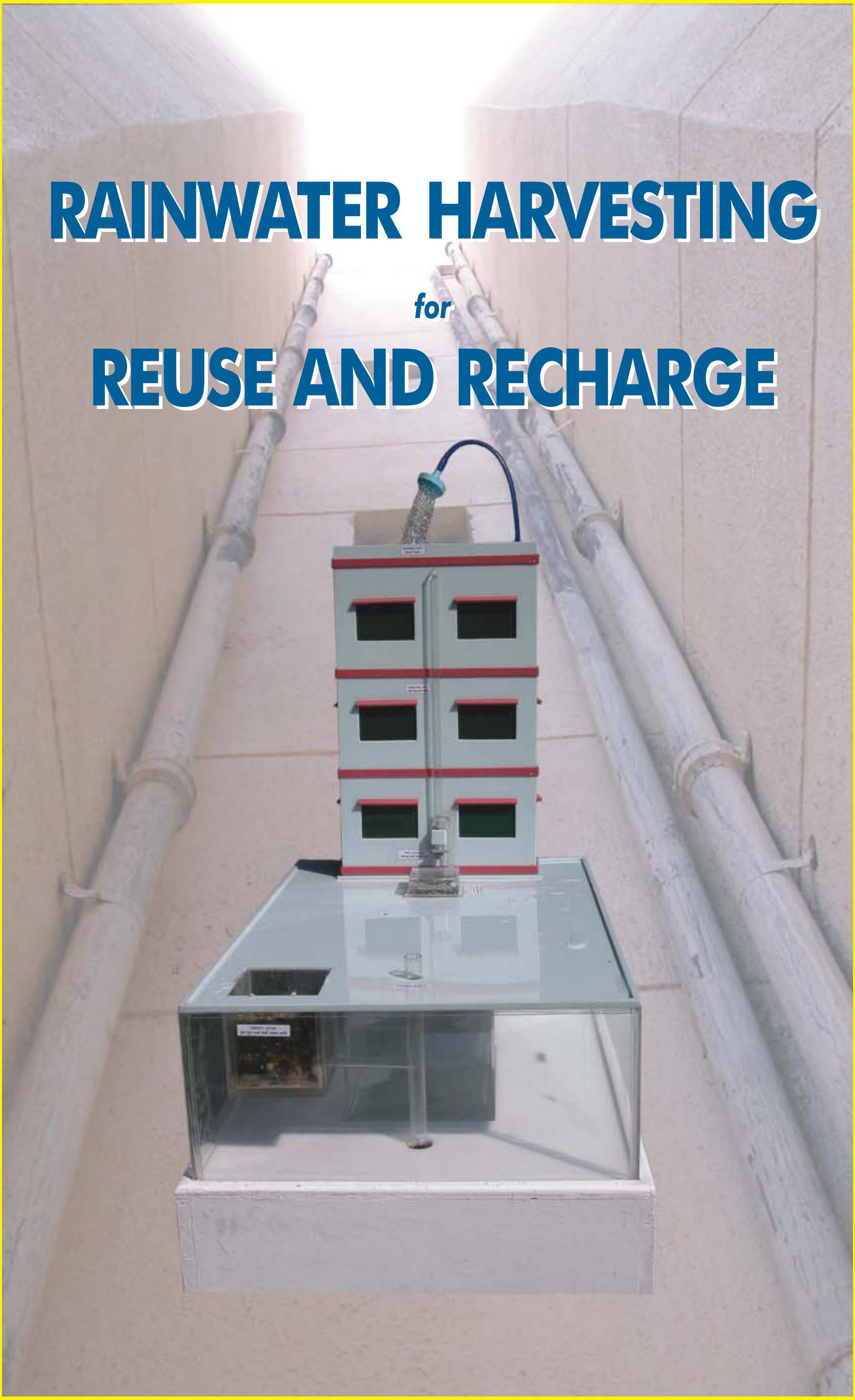
RAINWATER HARVESTING

for

REUSE AND RECHARGE



RAINWATER HARVESTING

for

REUSE AND RECHARGE

Supported by
UNICEF, Gandhinagar

Collaborating Agencies
Gujarat Jalseva Training Institute
&
Gujarat Water Supply & Sewerage Board

Design & Implementation

VIKSAT
Vikram Sarabhai Centre for Development Interaction
Thaltej Tekra, Ahmedabad - 380 054

Contents

Concept

Collection of rain water for immediate or later use is known as "Rainwater Harvesting".

Rainwater can be stored on the earth's surface in structures such as ponds, lakes, tanks and dams either for direct use or for recharge purposes. It may also be stored in storage tanks.

Rainwater can also be stored below the ground in the sub-surface dams, or injected directly into the aquifer through open/bore/tube wells.

Why Rainwater Harvesting has become important?

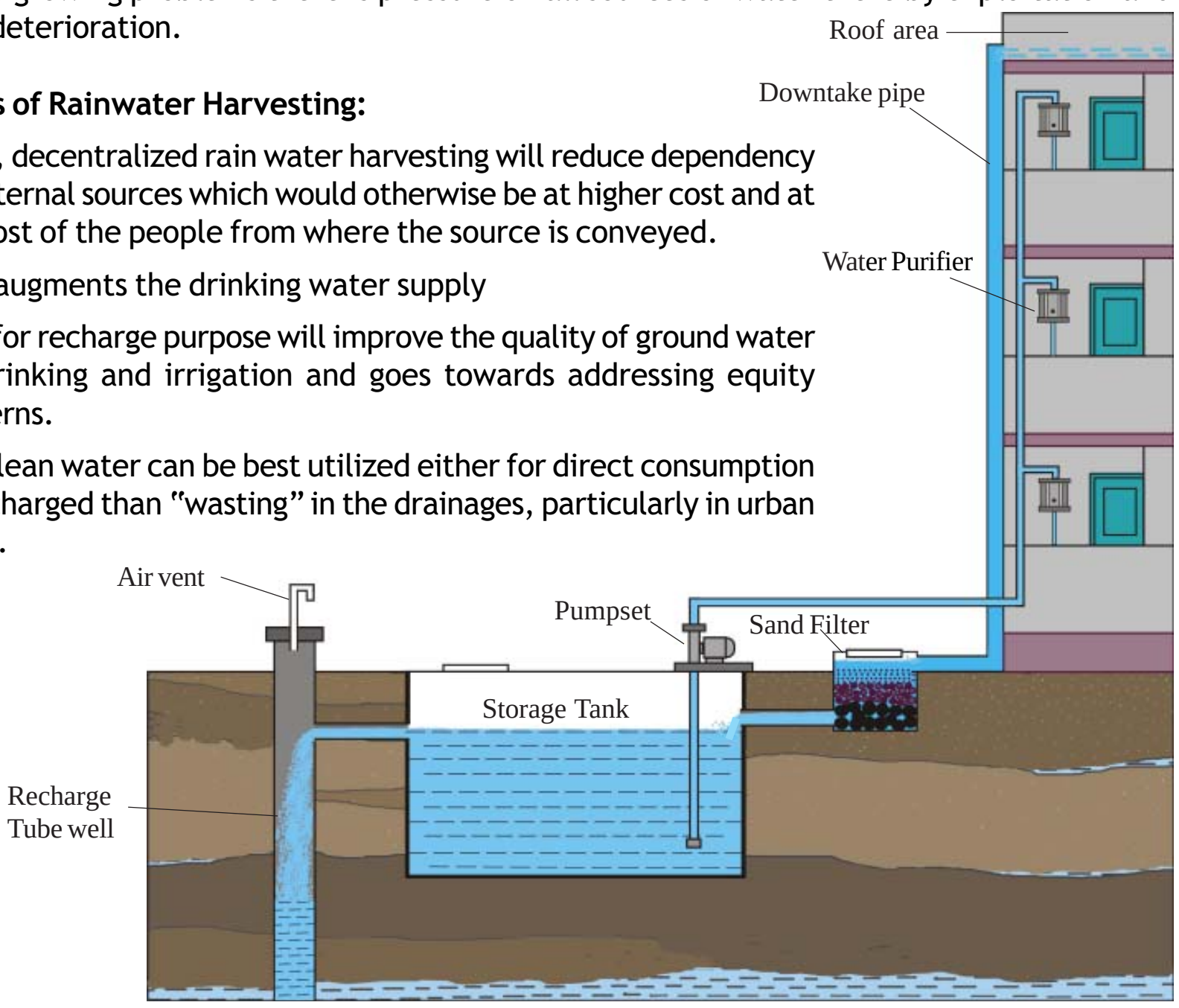
Provision of drinking water is the social obligation of the government. The government tries to meet the drinking water demand by pooling both surface and sub-surface resources. There is always a growing demand for drinking water as the population is growing and standard and style of living is changing. The following are some of the issues related to drinking water supply:

- In the rural areas, drinking water supply is sourced mostly from the groundwater.
- The demand is not adequately fulfilled due to limited availability.
- In the urban areas drinking water supply is usually from big dams across rivers or huge tanks & reservoirs.
- Accessing groundwater to augment drinking water needs of the household, colonies or institutions. Groundwater level has reached an alarming depth to deeper aquifers.

With the growing problems there is pressure on all sources of water there by exploitation and quality deterioration.

Benefits of Rainwater Harvesting:

- Local, decentralized rain water harvesting will reduce dependency on external sources which would otherwise be at higher cost and at the cost of the people from where the source is conveyed.
- RWH augments the drinking water supply
- RWH for recharge purpose will improve the quality of ground water for drinking and irrigation and goes towards addressing equity concerns.
- The clean water can be best utilized either for direct consumption or recharged than "wasting" in the drainages, particularly in urban areas.



Roof-top for rainwater harvesting

- Roof area offers excellent *Catchment Avenue* for harvesting rainwater, including for drinking purpose.
- Roofs of RCC, Tiled and G.I sheet are better suited.
- Roofs containing thatches, asbestos, wooden, bamboo should be avoided.
- Areas where acid rain possibility exists must be avoided. In other words, special care should be taken when RWH is planned in habitations in or around industrial areas,
- Roof top rainwater harvesting is best suited for areas with fluoride, iron, Arsenic and in other special problem areas.
- The cost of a rainwater harvesting system can be reduced if the design is integrated in the planning stage itself.

Options of Roof-top RWH

Reuse: Rainwater harvested from a roof can be used for drinking purpose by storing in a tank after proper filtration to remove dirt and floating materials, if any.

Recharge: Excess water harvested from the roof or the surface runoff can be recharged into the ground through recharge pits, dug wells or bore wells. Such a recharge activity, when carried out over a significant area, will help raise the groundwater level, apart from improving the quality of ground water.

Areas where RWH is appropriate

- RWH for drinking purpose has great relevance in Coastal areas where groundwater is saline and fresh water at shallow depth is limited.
- In hilly areas
    - Where groundwater occurs at deeper depths or for a limited period in a year; and,
    - Where drudgery exists in carrying drinking water from steep slopes.
- In geological terrains, where groundwater is not potable due to high concentration of Salts, Fluoride, Arsenic etc.
- In Urban areas, where Municipal water supply is rather limited and groundwater is either not potable or expensive to withdraw.

The Project

Project Title : LOCAL OPTIONS FOR SUPPLY AUGMENTATION THROUGH RAINWATER HARVESTING

Project Partners

Supported by : UNICEF, Gandhinagar

Planning, Design & Implementation : VIKSAT
Vikram Sarabhai Centre for Development Interaction
Thaltej Tekra
Ahmedabad – 380 054
Gujarat

Collaborating Agencies : Gujarat Jalseva Training Institute (GJTI), Gandhinagar
Gujarat Water Supply & Sewerage Board(GWSSB), Gandhinagar

Period : April 1, 2002 to October 31, 2003

Project Outlay : Rs. 26.36 lakhs
(RWH System + essential peripherals)

The project aimed at demonstrating the potentials of Rainwater Harvesting (RWH) for reuse and recharge purposes.

The project envisaged scientific installation of RWH systems in the institutional premises of Gujarat Water Supply and Sewerage Board at Gandhinagar.

The pilot demonstration models were successfully installed at:
Gujarat Jalseva Training Institute (GJTI) and
Gujarat Jal Bhavan (GJB)

Objectives of the Project

1. Establish two fully working cum demonstration models of RWH, one each at Gujarat Jalseva Training Institute and Gujarat Jalseva Bhavan in Gandhinagar.
2. Explore scope of linking rainwater harvesting to enterprise activity.
3. Provide orientation training to Engineers and Officers of both the institutions
4. Provide orientation training to other Government Officers and NGOs and
5. Document the experiences and dissemination.

I. Implementation

1. Steering Committee

- Monitor the progress of implementation and suggest mid-term corrections if any;
- Scrutiny of tenders and selection of Contractors for civil constructions
- Members : Mr. Arun Mudgerikar (Programme Officer, UNICEF, Gandhinagar)
  Mr. K.K. Jadeja (Chief Engineer and Director, GJTI) and
  Mr. Srinivas Mudrakartha (Director, VIKSAT).

In addition to formal Steering Committee meetings, there were quite a few informal consultations among the committee members to take care of implementation related matters.

2. Working Group

- Discuss and ratify the designs prepared and presented by VIKSAT.
- Members : Key staff of GJTI, GWSSB and VIKSAT and Programme Officer, UNICEF.
- In addition, there were also informal consultations between concerned Engineers from GJTI/ GWSSB, VIKSAT as and when required.

◀ Working Group members on a visit to project sites ▼

II. Procedure adopted for implementation

1. Preliminary Feasibility Survey

Preliminary Feasibility Survey carried out in both GJTI and GJB premises.

- Measurements such as Roof area, length of the conveyance system and other existing pipe lines were made for design purpose.
- Site selection was made for the conveyance and storage structures.

2. Data and Maps Collected

Primary Information

- Building plans;
- Existing supply storage and distribution system;
- Daily water demand, supply and consumption details;
- Layout of drainage system;
- Location and accessibility of existing rainwater drain pipes; and,
- Details of existing tube wells (defunct) and an open well, including lithology.

Secondary Information

- Literature Review for Technical details on filter systems;
- Hydrogeological data of Gandhinagar;
- Rainfall and other meteorological data;
- Information collection on PVC pipes, netlon etc.

Key elements of the data collected for GJTI RWH Activity

- Area of the premises : 10,000 sq.m.
- Building area : 1,612 sq.m.
- Paved area : 2,895 sq.m.
- Unpaved area : 5,493 sq.m.
- Institute's roof area : 743 sq.m.
- Workshop roof area : 230 sq.m.
- Two defunct tube wells (hand pumps) for recharge purpose.

Key elements of data collected for GJB RWH Activity

- Area of the premises : 4,707 sq.m.
- Total roof area : 1,927 sq.m.
- Total outside passage : 1,955 sq.m.
- Total inside passage : 824 sq.m.
- Entire compound area is paved.

The average annual rainfall of Gandhinagar is 600 mm.

3. Design of RWH systems

- Preparation of the designs and estimates for various components of the RWH systems in both the institutions – GJTI and GJB was prepared by VIKSAT;
- These designs were presented to the Working Group comprising GJTI and GWSSB Engineers, Geologists, Geophysicists and Water Quality Analysts apart from members of the Steering Committee and the Working Group at **Gujarat Jalseva Training Institute (GJTI)** conference room on August 17, 2002;
- The designs presented for reuse and recharge systems in GJTI were accepted with minor suggestions, which were later incorporated.
- With regard to **Gujarat Jalseva Bhavan (GJB)**,there was a space constraint for establishing reuse structure. So, the participants along with UNICEF and VIKSAT personnel made site visit to GJB on the same day after the meeting.
- During the site visit it was suggested to explore a small square plot behind the GJB campus and within the GRHB campus which appeared ideal for establishing the storage structure and that GRHB should be approached for permission.
- GRHB was approached for permission; but GRHB Board alone is authorised to consider requests for such permission. However, due to Assembly elections scheduled (in December 2002), the decision from GRHB was delayed; hence the idea was dropped.
- In the Steering committee meeting held on January 30, 2003 it was decided to install only the recharge structure in GJB.

4. Tenders & Contracts

For RWH system in GJTI:

- **Sealed Tenders** were invited for construction of storage tank and other civil works through advertisement in the local Newspapers.
- **Tender Opening** meeting Organized; H.B. Infrastructure, Ahmedabad, was selected as the contracting agency (contractor).
- **Work Order** issued to the contractor and techno-managerial agreement was signed between VIKSAT and H.B. Infrastructure.

For RWH system construction in GJB:

- **Sealed Quotations** invited from two experienced tube well construction agencies for constructing recharge tube well.
- **Sealed Quotations** opened; Sri Hari Tube well Company, Ahmedabad, awarded the job of tube well construction.
- **Agreement** signed between VIKSAT and the agency.
- **Work Order** issued to Shri Hari Tube well Company for the construction of a recharge tube well.

The construction agency appointed for civil works was common for GJTI and GJB.

Work Initiation permission was obtained from both GJTI and GJB before starting the actual implementation work on site.

Rainwater Harvesting Potential					
GJTI Premises:		lakh litres	**GJB Premises:**		lakh litres
From the entire campus area	-	**24.00**	**From the Premises**	-	**22.60**
From all building roofs	-	**6.30**	**From entire roof area**	-	**9.25**
From Training Institute roof area	-	**2.67***	**From 50% roof area**	-	**4.60**
From Workshop roof area	-	**0.83***	(Presently, 50% roof area tapped for recharge purpose)		
(*Only 3.5Lakh litres tapped for Reuse and recharge purposes)					

III. Implementation of RWH system for Reuse and Recharge purposes in GJTI

1. Marking of Layouts:

Marked layouts for structures such as horizontal and gravity filters, and the storage tank in GJTI as per designs .

2. Excavation and Civil Works:

Excavations were carried out for the storage tank, filter pit, plumbing work, manholes, open drain and roughing filter.

◀ Excavation for Gravity Filter

Reinforcement ▶ Steel and Shutter fixing for Storage Tank

3 Plumbing work:

- Plumbing work consisted of connecting the existing rainwater drain pipes from the roof to the underground pipes to connect with the RWH system for conveyance.
- Connected the existing rainwater C.I. pipes to the newly laid 6" PVC pipes & provided first flush valves.

◀ Existing C.I. Pipe connected to Rainwater Conveyance Pipe

First Flush ▶ Valve fixed to the Rainwater Conveyance pipe

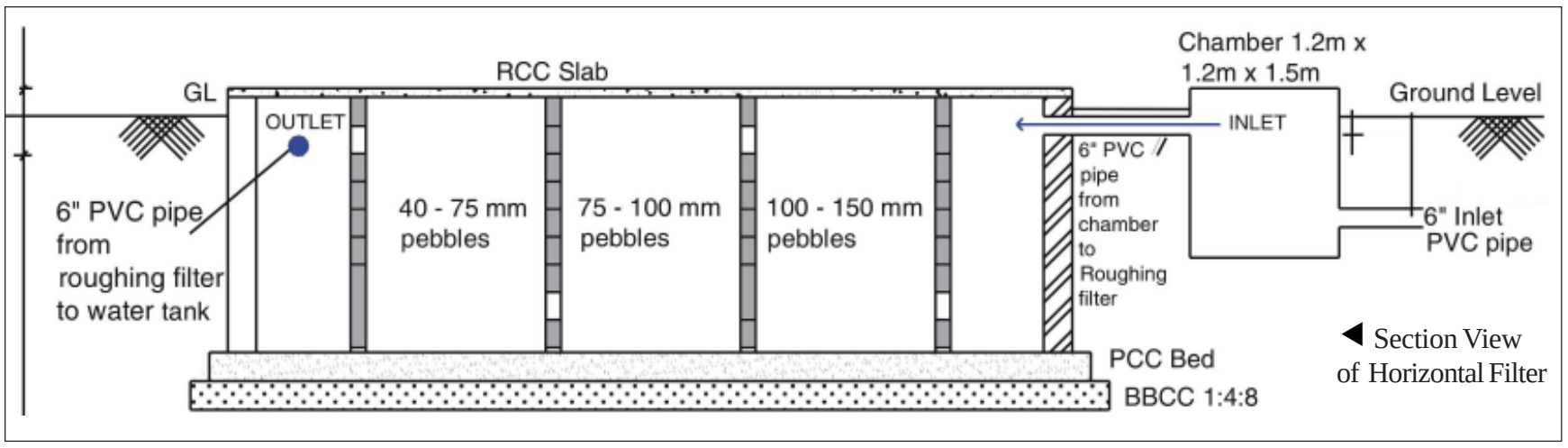
4. Manhole Chambers:

5 manhole chambers were constructed for channelising and diverting rainwater.

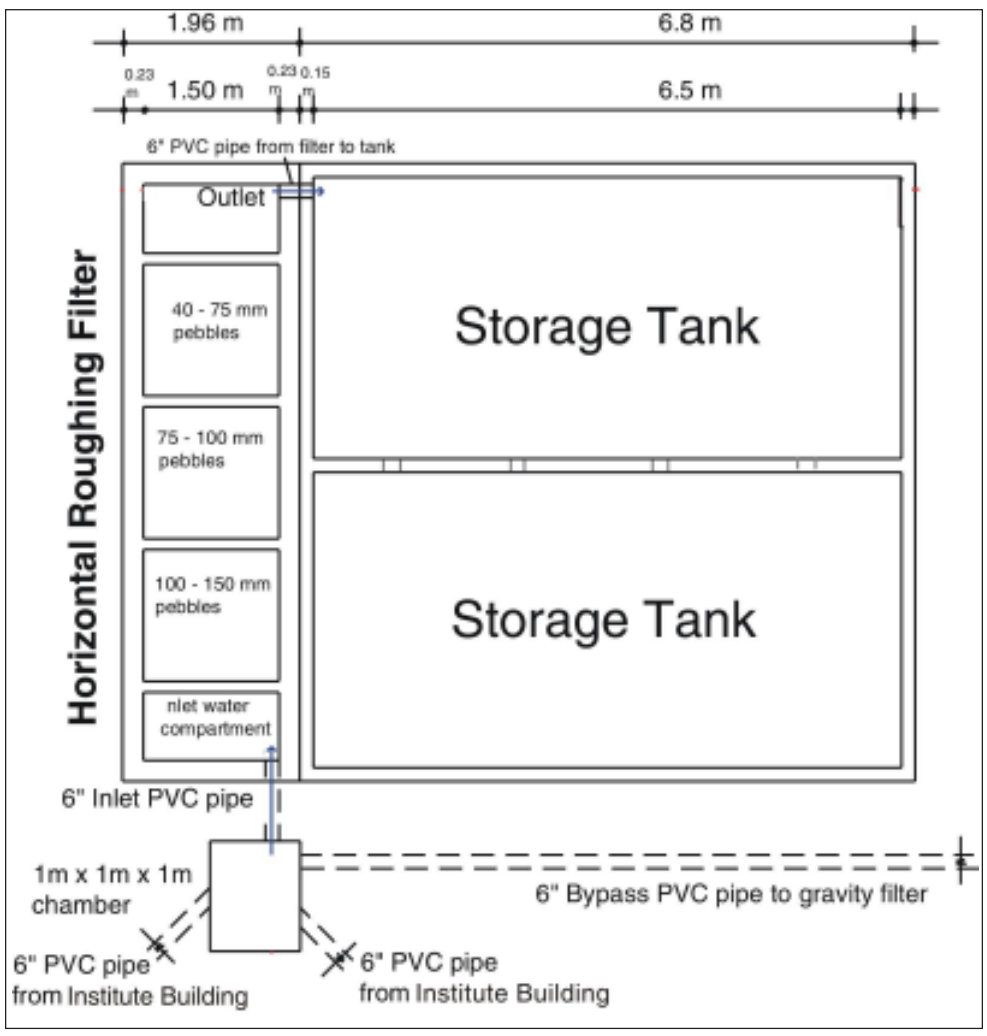
5. Horizontal Roughing Filter:

Horizontal Roughing Filter (HRF) consists of 5 chambers interlinked with openings of appropriate sizes. The sizes of the openings depend on the size of the gravel laid in the particular chamber.

Rainwater ▶ from the roof is conveyed to the common chamber and then to the Horizontal Filter



◀ Section View of Horizontal Filter



◀ Plan view of Horizontal Filter and Storage Tank

Openings in Horizontal Filter - GJTI ▼

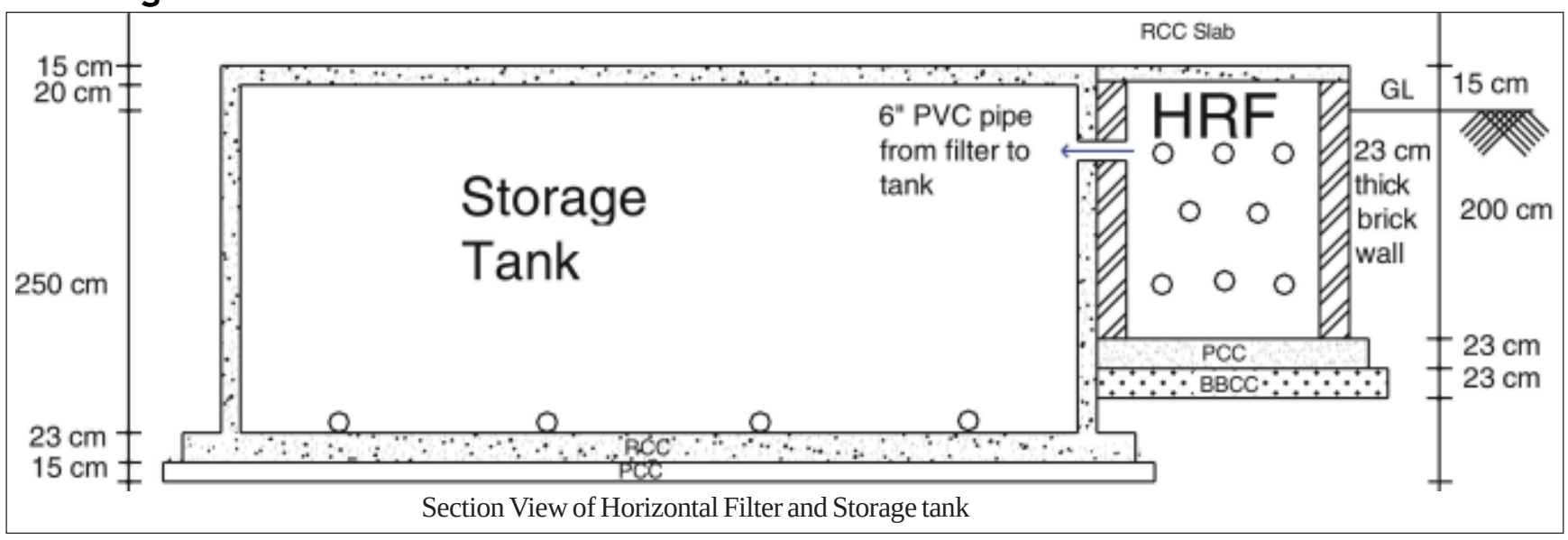
The openings are placed in such a way that rainwater passes through entire column of the chamber for effective filtration.

Settlement Chamber:
The turbulence of gushing rainwater is reduced. The dirt carried by the rainwater is settled at the bottom.

Filter Chambers:
The middle three chambers are filters filled with gravels. Each chamber has different sizes of gravels, like 100-150mm pebbles, 75-100 mm pebbles and 40-75 mm pebbles respectively in that order.

Storage Chamber:
The last (5th) chamber stores filtered water and conveys to the storage tank.

6. Storage Tank



Section View of Horizontal Filter and Storage tank

- The storage tank is an RCC structure of 1 lakh litre capacity.
- It is constructed adjoining the HRF to avoid problems in conveyance.
- Storage tank is partitioned with a 4" thick wall and interconnected by openings at the bottom.
- This partition wall supports the RCC slab cover as the span is large.
- All the inner walls of the storage tank are lined with Ceramic tiles for easy cleaning and maintenance.

Storage Tank with Air vents ▲

- An over flow pipe is provided at the opposite end at the top.
- The top of the tank is raised 6" above the ground level to avoid soil depositing on the cover slab.

7. Gravity Filter

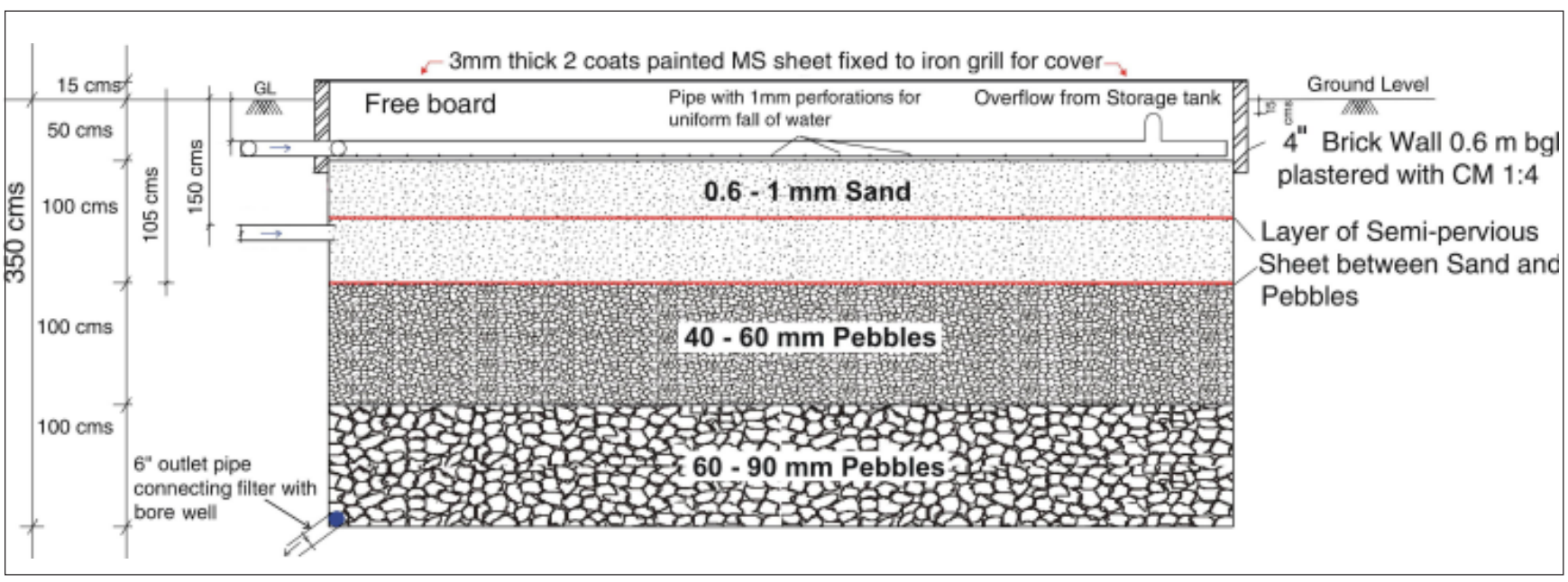
- Gravity filter is a part of the recharge system.
- The filter chamber has a depth of 3m and the bottom is kept open for seepage of water.
- A 6" PVC pipe connects the filter to the recharge tube well at the bottom.
- Rainwater gets filtered through three layers of filter materials.

Top Layer : 0.6-1mm coarse sand of 1m thickness

Middle Layer : 40-60mm gravel of 1m thickness

Bottom Layer : 60-90mm gravel of 1m thickness

Gravity Filter - PVC Pipe laid in U shape with Steel Grill Cover ▶



- A netlon sheet is spread between the top sand and middle gravel layers to avoid clogging of voids in the gravel by sand particles.
- Over-flowed rainwater from the storage tank and from the bypass pipeline are diverted to this filter through 6" PVC Pipes. .
- The PVC pipe in the filter chamber is laid in such a way that the rainwater spreads equally throughout the filter through small openings provided in the pipe at the bottom. This will not disturb the sand layer and ensures efficient filtration.

8. Recharge structure

- A drain of 2'x 2 1/2' dimension with a 4" thick wall is constructed near the workshop area for collection of surface run off for recharge purpose.
- Rainwater harvested from surface flow around the workshop, roof of the workshop and the drain are conveyed to the gravity filter and then recharged into the aquifer through the existing tube well.

Gravity filter connected to the tube well - Recharge system in Workshop area - ▲

9. Cleaning of existing two tube wells (hand pumps):
Existing two tube wells were cleaned using air compressor and tested for rate of recharge by pouring 3000 litres water. These tube wells were then connected with the respective gravity filters through 6" PVC pipes.

Gravity filter covered by MS Steel sheet fixed to steel Grill - Minimum maintenance ▲

10. Covering the filters and the drain:
Both the gravity filters and the open drain near the workshop are covered with iron grills fixed with 3 mm. mild steel sheets. This will prevent contamination by bird droppings, fallen leaves and any other waste matter and also ensures safety.

11. Re-laying the excavated trench:
The excavated earth was re-laid on the ground and leveled with a proper slope to drain-off storm water.

12. Reuse system:
For the reuse of collected rainwater in the storage tank, 1 H.P. monoblock pump has been installed. A 300-litre PVC tank has been placed above the pump room with a tap connection.

Reuse system -Provision of Dispenser tank ▲

13. Fencing of RWH systems:
G.I. Chain link fencing of 5ft. height fixed to L-angles placed at 10ft. distance apart has been provided around the RWH systems. A barbed wire has been wound to the fence on the top in both the RWH systems.

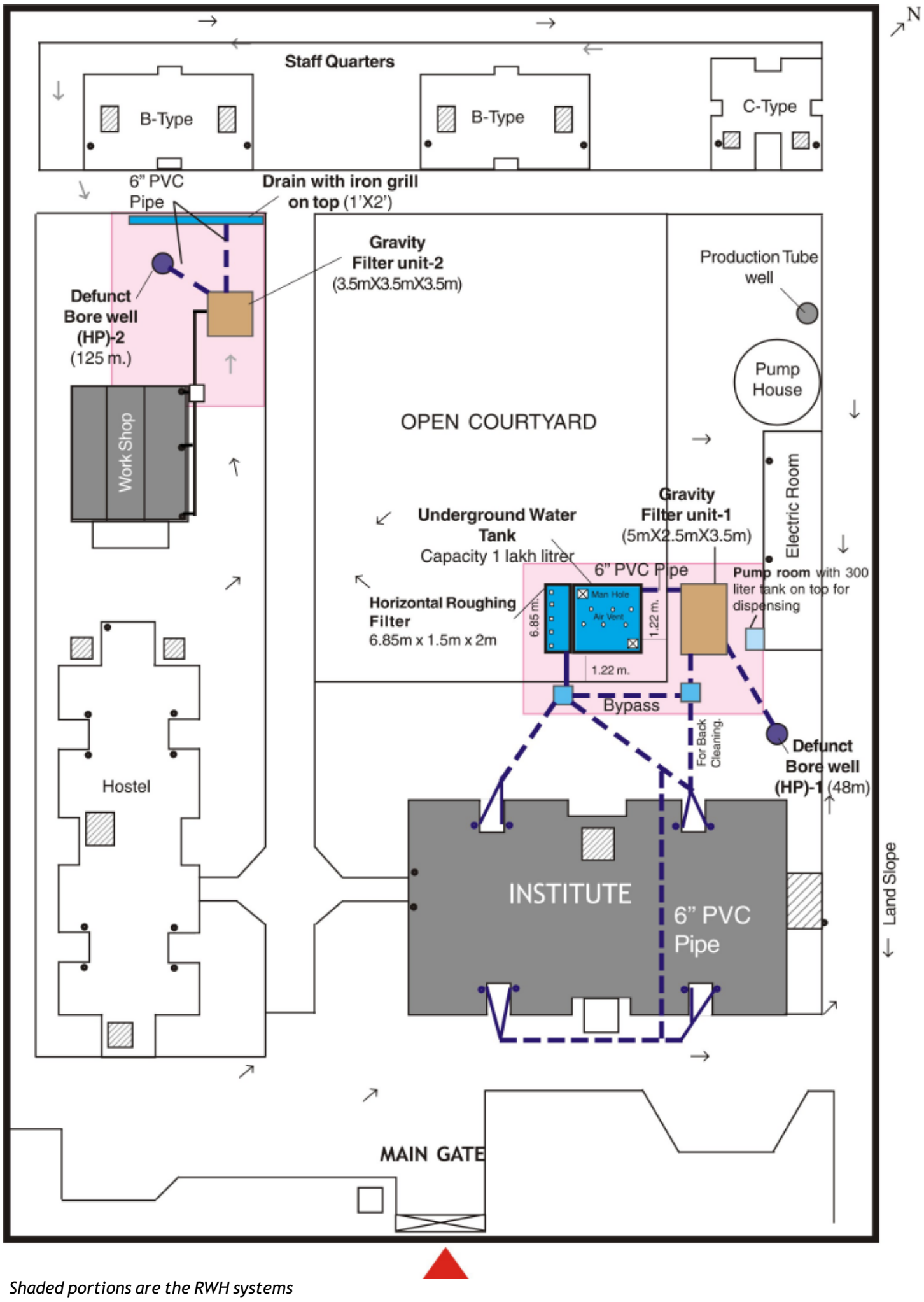
Accrued Benefits

The harvestable runoff available from the entire premises is 24 lakh litres for an average annual rainfall of 600mm.

About 3.5 lakh litres of rainwater is harvestable from the Institute's roof.

After storing 1 lakh liter for reuse purpose, the remaining 2.5 lakh litres is recharged into the aquifer.

Still, with a little more investment on just the pipelines, the remaining potential from the hostel and staff quarters buildings can be utilised. The water thus harvested may be used for both reuse and recharge purposes.



Shaded portions are the RWH systems

IV. Implementation of RWH system for recharge purpose in GJB

1 **Marking of Layouts:**
Layouts were marked on the ground for the conveyance system from the raindrop pipe points to the recharge tube well site.

2. Excavation:
Excavation of concrete pavement was carried out for the plumbing and for the construction of manholes.

3. Manhole Chambers:
9 manhole chambers were constructed along the conveyance pipe line for the purpose of maintenance.

4. Plumbing work:
Plumbing work involved connecting the existing rainwater C.I. pipes at 7 places with the PVC pipes & providing first flush system by fixing PVC valves. The PVC pipes laid underground were connected to tube well.

First 45m. of the rainwater conveyance pipe in the parking area is of G.I. (as per the request of GJB.)

▲ Trench dug for laying PVC pipes for conveying rainwater

▲ 6" PVC Pipes laid in the trench

5. Recharge Tube well
A new recharge tube well is constructed to inject rainwater directly into the aquifer.

The tube well is 8" dia (final) and constructed to a depth of 200ft. to recharge current production aquifer.

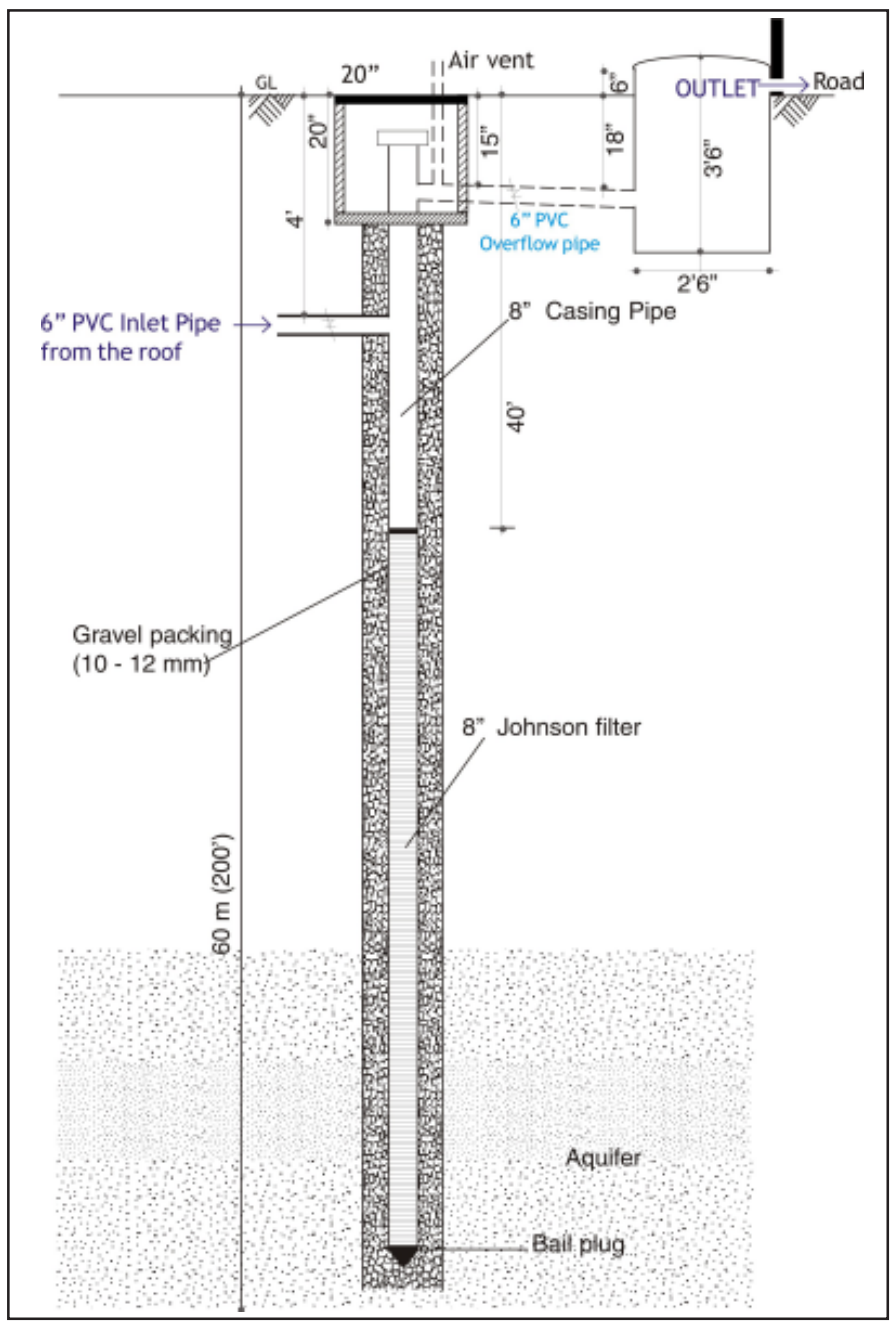
Rainwater conveyance pipe is connected to this tube well at a depth of 4ft. below the ground.

Detailed design is shown below:

6. Overflow system:
Over flow structure is provided near the rarely used (2nd) gate on the left side of the premises.

This structure discharges excess rainwater from the recharge tube well thus avoiding flooding in the compound.

Tube well is connected to over flow structure by a 6" PVC pipe.



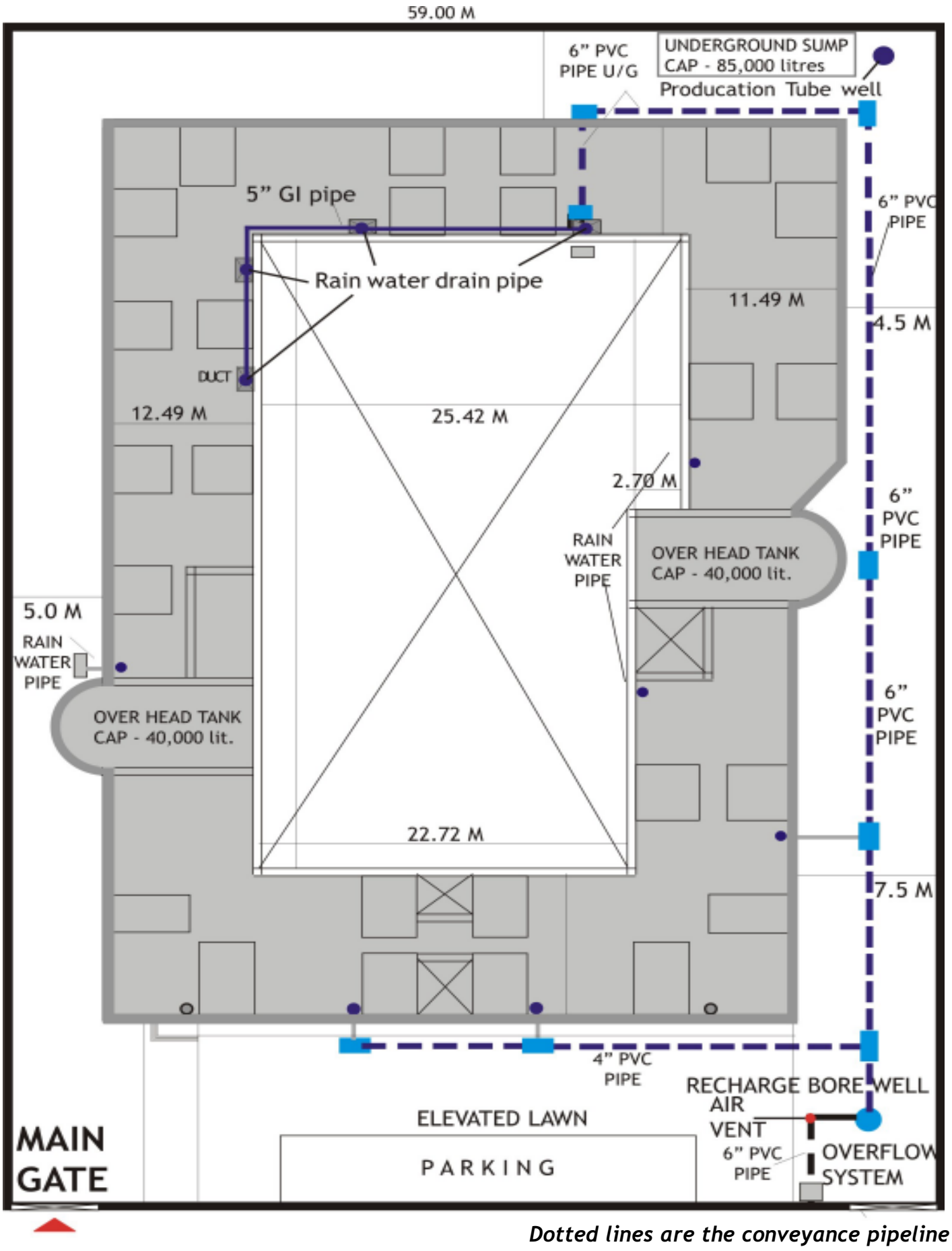
An air vent is provided to dispalce air when heavy rainwater gushes in the conveyance pipe and the recharge tube well

7. Relaying the excavated trench:

The excavated portion of the pavement in the premises was relayed by first filling the trench with sand, over-lain by PCC and then by RCC. The left out and the tube well excavated earth was disposed off.

Layout plan showing Recharge system in GJB

The following plan shows the conveyance pipe line (thick dotted lines), location of manhole chambers and the location of the recharge tube well in the premises:



Dotted lines are the conveyance pipeline

Potential Benefits

- The potential harvestable runoff available from the entire premises is 21 lakh litres for an average annual rainfall of 600mm.
- This Rainwater Harvesting System is designed to recharge 4.6 lakh litres as it taps only half the roof area of 963 sq.m.

V. Drinking Water Security in GJTI

- For about 100 staff working at GJTI, at the rate of 2 litres percapita on an average, about 200 litres of water is to be drawn from the rainwater harvested storage tank. For 240 working days in a year, it requires to withdraw 48,000. Whereas the storage tank has the capacity to store 1 lakh litre of rainwater.
- A 300-liters HDPE tank is provided near the RWH system to store water.
- A support staff of GJTI has been assigned the job of carrying water daily by Carboys and pours into the water coolers placed one in each of the three floors.
- Drinking water that was earlier coming from the over-head tank has been closed. Hence, the staff is drinking rainwater since the beginning of this year monsoon.

'***VARSHAMRIT***' is the name coined by VIKSAT to the purified rainwater that is poured into the coolers for drinking purpose. The name is derived from the ancient Indian language *Sanskrit* meaning *Varsha* = Rain and *Amrit* = Elixir of life

Varshamrit - Rainwater carried in Carboys for pouring in coolers ▶

A general enquiry with the staff of GJTI on the perception of taste of *Varshamrit* revealed that the water quality is better than the tube well water and every one likes to drink rainwater only.

VI. Inauguration of the GJTI RWH system

The RWH system in GJTI for reuse and recharge purposes was inaugurated by Honourable Minister for Narmada Water Resources Mr. Narottambhai Patel on 31st July 2003.

Mr.Arun Mudgerikar, Project Officer, UNICEF, Gandhinagar, Mr. K.K. Jadeja, Chief Engineer cum Director, GJTI, Mr. Srinivas Mudrakartha, Director of VIKSAT, other invitees and the staff of VIKSAT and GWSSB attended the inaugural function.

In his inaugural address, the Minister emphasized on the the need for implementing such RWH systems in all the Departmental buildings in Gandhinagar in view of the ever increasing drinking water problems. Mr. K.K. Jadeja and Mr. Arun Mudgerikar also spoke on the occasion.

He was taken around the structures by VIKSAT Director who also explained the functions of various components. The Minister expressed his happiness for establishing RWH system in the GJTI premises.

Hon'ble Minister going round RWH systems in GJTI and Inaugurating *VARSHAMRIT*

VII. Perceptions of Users

The RWH systems were established well before the advent of monsoon (of 2003). After the inauguration of the system by the Hon'ble State Minister, arrangements for supply of drinking water were put in place. A person was identified to carry *"Varshamrit"* in carbuoys and fill the water coolers in all the three floors. We interviewed a few staff members to obtain their perceptions on the rainwater.

"The rainwater tastes so good and clear!" exclaimed Mr. S.M. Shah, Executive Engineer and Administrator of the Institute building. He felt relieved at the alternative to the saline taste of the existing tube well water.

A driver of long years in GJTI believes that *"the potable quality drinking water being supplied now would, over a period of time relieve, or, at least reduce his knee joint pain"*.

The family members of the staff residing in the quarters in the premises are quite enthusiastic about using rainwater daily for drinking and cooking purpose. A woman member hoped that this rainwater would *"help her and her family to get rid of the yellowness on teeth"*; *"which is an indication of excess fluoride in the ground water supplied so far for drinking"* added a watchman. GJTI has a full fledged water analysis laboratory; no wonder that support staff are also aware of the quality problems.

VIII. Signages

- Signages/posters depicting technical plans and designs of each component of the RWH systems have been put up in both GJTI and GJB, along with the details of potentials and benefits.
- Posters contain appropriate explanation about the materials used,designs and dimensions to make them self-explanatory.
- Similarly, caution notices on acrylic plates are fixed near the rainwater drop pipes to distinguish them from other pipes running parallel to each other; this will also help avoid contamination with sewage pipes even by mistake.
- Appropriate instruction signages are put up near the first flush valves.

IX. Dissemination of the experience

One of the objectives of the project was to disseminate the concept, share the experience and create awareness on the benefits among various sections of the Society.

Under this, 5 training programmes were conducted for different groups such as engineers, builders, teachers/students, general public and NGOs. The topics covered under these interactive training sessions included:

- General scenario on water resources in the world, South Asia, India and Gujarat.
- Recent trends in drinking water scarcity situation in both rural and urban areas of Gujarat.
- Various methods of rainwater harvesting for reuse and recharge.
- Discussion on rainwater harvesting systems for institutional, industrial, residential societies and individual buildings established by VIKSAT.
- Potentials and benefits of rainwater harvesting.
- Rainwater as a decentralised option in achieving drinking water security.

▶ Sabarmati Stake-holders Forum including Industry group participating in the Training Programme

◀ Teachers & Students Participating in the Training Programme - Enlarging the scope for scaling up

▶ Societies and Builders Participating in the training

◀ Hon. Minister Mr. Narotthambhai Patel and Director & Engineers from GWSSB & GJTI attending training

The broad theme of the training programmes was '*Decentralised Local Options for Supply Augmentation through Rainwater Harvesting*'.

Sr. No.	Participants	Date	Number of participants	Experience shared by
1	Engineers and officers from GWSSB and GJTI	31st July 2003	50	Srinivas Mudrakartha and Mansi Mandan
2	NGOs	22nd August, 2003	22	Srinivas Mudrakartha, Srinath, Vijay Kaushal, Mansi Mandan and Anand Kumar
3	Members of Sabarmati Stakeholders Forum	26th August 2003	20	Srinivas Mudrakartha, Srinath, Vijay Kaushal, Mansi Mandan and Anand Kumar
4	Teachers & Students from schools and colleges	20th September 2003	22	Srinivas Mudrakartha, Srinath, Vijay Kaushal and Venkataramana
5	Housing Societies & Builders	21st September 2003	15	Srinivas Mudrakartha, Srinath, Vijay Kaushal and Venkataramana

Exposure visit to working models was part of all the above trainings. Participants were taken to GJTI, GJB, N.M.Kapadia's house (individually owned RWH system for the household consumption) in satellite area, Ahmedabad and Gujarat Oncology Centre, Vasna, Ahmedabad to show different models of RWH systems implemented by VIKSAT.

Outcome and suggestions from the Training

- More number of orientation programmes and technical guidance to the housing societies is essential. They also requested technical support for establishing RWH structures.
- Technical assistance for installing RWH structures was sought by industry.
- Follow up with the Government for policy advocacy to provide incentive for taking up RWH.
- Introduction of RWH concept in the school and college curriculum.
- Formation of RWH Clubs in Schools and Colleges for promotion in the residential areas and institutions.

X. Documentation

The experiences gained during implementation have been documented for the purpose of dissemination among various groups such as individual households, Research and Academic Institutions, Government Departments and Non-governmental Organisations.

The project endeavoured to address drinking water problems such as quantity, quality, accessibility and reliability and to have water security through RWH.

The following materials have been developed:

- Leaflets providing technical details of the RWH systems in GJTI and GJB.
- Operation & Maintenance manual for GJTI and GJB.
- VIKSAT's experience in the promotion of RWH models in various institutional premises.
- Signages / Posters for GJB and GJTI.
- Process documentation of the RWH construction in GJTI and GJB.

XI. Enterprise Activity

The storage tank has a capacity of 1 lakh litres of harvested rainwater. As the consumption of harvested rainwater for drinking purpose by 100 staff members is only 48,000 litres (@2 litres percapita/day for 240 working days) in a year, the remaining 52,000 litres could be used for enterprise activity. (However, this year, 2003, this excess water was supplied to trainees in the hostel.)

In other words, even if we assume a cost of Re.1/- per litre, the GJTI RWH system cost could be recovered in 3-5 years.

In addition, there will be other basic benefits of improved health of the staff due to consumption of good quality water.

XII. Costing of various RWH Components

S.No	Item	Rs.
1	GJTI- Conveyance	3,09,724
2	GJTI- StorageTank	2,94,883
3	GJTI- Filtration Tank	66,815
4	GJTI- Recharge System	52,159
5	GJTI-Reuse System	14,066
6	GJB- Conveyance	3,67,651
7	GJB-Recharge System	1,23,210

The costs include other peripheral works which are strictly not part of the RWH but are considered essential such as the fencing around the RWH structure for the purpose of safety.

Conclusion

Gujarat State has varied rainfall from South to North west with scanty rainfall of average 350mm in Kachchh District.

Narmada River is considered to be a boon for the Gujarat State as it is fulfilling the drinking water needs in many parts of the State. Narmada canal crossing over many Northern districts are supplying drinking water to hundreds of urban and rural households.

Apart from this Dharoi dam across the River Sabarmati is catering to the drinking water needs of a few tens of villages in Mehasana District.

All these demands are met from external options, which are beyond the control of the people or the government (for some natural reasons). Thus, water security for the people in the areas covered and to be covered areas is still to be achieved.

Any solutions, preferably from local options, will have long-term benefits for the people as they will thenselves be shouldering the responsibility.

RWH systems established in GJTI and GJB demonstrate the viability of such local options for reuse and recharge purposes.

The RWH system established in GJTI (a premier Institution in the State for training on drinking water and its management), has become a demonstrative, working model for trainees from diverse regions to see and learn the conceptual and practical aspects.

The signages put up provide technical details including harvestable potentials from each of the systems and help motivate visitors.

The recharge system in GJB is a standing example as an option for groundwater recharge from roof-top harvested rainwater.

The various components established provide clear understanding of the RWH system for recharge purpose and the caution notices would give messages on the precautions to be taken while adopting such systems in any premises.

Large scale adoption through more publicity on rainwater harvesting as a local option for the individual household, community, institutions and government departments is likely to address the scarcity of drinking water problem in Gujarat State. This would also have a direct bearing on the health and quality of life of the people.

The United Nations has very appropriately declared the year 2003 as the "*International year of freshwater.*"

Ways Forward

It is proved beyond doubt that drinking water security can be ensured by rain (rooftop) water harvesting, whether at household level, residential societies or large public institutions. For instance, in the case of GJTI, hardly 15% of the potential is used currently; the RWH system is so designed that the coverage can easily be extended to its full capacity for a combination of storage and recharge.

It is beyond doubt that the quality of rainwater is excellent, although it may not have the "mineral" contents. Rain water is available in all areas which can be captured, filtered/treated and used for drinking water. Thus, it is a decentralized source which provides self-reliance. It has particular application in urban areas as otherwise the run off gets mixed with city sewage and becomes wasted.

Such a decentralized source can also be linked with entrepreneurship much on the lines of the "milk" pattern. This aspect needs further study and experimentation.

On the recharge front, rainwater has great potential to reduce the demand-supply gap. A proper area planning will help raise ground water levels.

Such a rebuilding of ground water levels is possible only when the rainwater recharge takes place on a scale. Technical support is essential for proper designing and implementation as standardized designs are not suitable for all situations. Although the principles of recharge may appear very simple, absence of proper technical design has potential for damage.

The driver for the success of rainwater harvesting lies with the government. There is a need for both "incentives" as well as "regulations". It will not be a day sooner even if such policy changes are made forthwith and implemented properly.

Operation & Maintenance of Reuse and Recharge systems in GJTI

1. Institute roof and Workshop roof area

- Trim the branches of trees hanging over the roof to prevent contamination by leaves and bird droppings;
- Clean the roof and remove the algae formation if any, before the onset of monsoon.

2. Conveyance System

- Inspect down pipes, particularly when it is raining, so that leaks can easily be detected. Clean them before the advent of monsoon and also when there is a long gap between the spells to remove dust and other contaminants.
- Remove sediments from the manhole / chambers before the advent of monsoon.
- After the monsoon, drain the stagnant water in the pipes in to the filter pit near the storage tank by operating the valve in the chamber located in front of the Gravity filter.
- Clean the conveyance drain in the workshop area before the onset of monsoon.

3. Horizontal Roughing Filter

- Clean the first and the fifth chamber (which do not have any filter materials) before monsoon.
- Before the advent of monsoon, take out pebbles from the filters, clean and fill it back. This should be carried out every year.

4. Gravity Filter Unit

- Remove the top 0.5 m thick coarse sand above the netlon sheet. Wash, sieve and then re-lay the sand just before the onset of the monsoon.
- Wash and Clean the U-shaped PVC pipe placed along the periphery of the gravity filter unit at least once before the onset of monsoon.

5. Storage tank

- Clean the storage tank of 1 lakh litre capacity before the onset of monsoon when the tank is empty.
- Ensure that the lids are in its place and there are no gaps. This will avoid entry of sunlight which otherwise allows growth of Algae and entry of insects and worms. Remove dust and leaves around the lid.
- Ensure that the air vent pipes on the storage tank are closed with nylon net to prevent entry of insects and Mosquitoes.
- Chlorinate @2 mg/litre of water in case some contamination is detected/suspected.
- Monitor water quality for potability for samples taken from the storage tank on a regular basis.

Analyse water quality for the following parameters:
Date of water Sample of collection:
Date of Analysis:

Sr. no	Parameters	Desirable limit	Permissible limit in the absence alternate source	Analysed value
	Physical Characteristics			
1	Colour Hazen units	5	50	
2	Odour	Unobjectionable;		
3	Turbidity, NTU	5	25	
	Chemical Characteristics			
4	Total Dissolved solids	500 mg/l	1500 mg/l	
5	pH	7.0 – 8.5	6.5 – 9.2	
6	Hardness (as CaCO3)	75 mg/l	110 mg/l	
7	Calcium	75 mg/l	200 mg/l	
8	Magnesium & Sodium	500 mg/l	1000 mg/l	
9	Chlorides	200 mg/l	600 mg/l	
10	Sulphates	200 mg/l	400 mg/l	
11	Nitrate	45 mg/l	100 mg/l	
12	Fluorides	0.5 mg/l	1.5 mg/l	
13	**Biological & Micro-organic**	Nil	1 Coliform colony per 100ml or MPN of B-coli is limited to 1 per 100ml	

6. Drinking Water Dispenser System

- Clean the 300-litre dispenser tank regularly (at least twice in a month) to ensure pure and safe drinking water.
- Use a small 'tap filter' before collecting water from the tank for drinking purposes.
- Keep the pump room under lock to avoid over use of stored rainwater.

7. Existing Tube Wells (Hand pump)

- Strictly ensure that no grease, oil or any other solid impure material gets mixed with water that flows into the RWH systems. This will reduce the recharge capacity, in addition to contaminating the system.
- Install water meter on the conveyance pipe to monitor actual quantum of water recharged.
- Measure water levels in the pumping and recharge tube well using Water Level Indicator on fortnightly basis from May to October to observe raise of groundwater table.
- Monitor Water Quality for all parameters of potability for samples taken from pumping tube well every month from May to October.

PRE-MONSOON OPERATION & MAINTENANCE-CHECK LIST

Catchment area (Institute & Workshop roof)			**Date**
●	Cleaned the terrace	Yes/No	
●	Checked the condition and position of iron net (*jali)* fixed at the inlet of rainwater pipe	Yes/No	
●	Trimmed the hanging branches on the roof	Yes/No	
Conveyance system			
●	Cleaned the manhole chambers	Yes/No	
●	Kept open the first flush valve to drain the first rainwater	Yes/No	
●	Cleaned the drain before the onset of monsoon	Yes/No	
Horizontal Filter			
●	Cleaned the First and fifth chamber	Yes/No	
●	Removed the pebbles from each chamber, washed, dried and filled back into respective chambers.	Yes/No	
Gravity Filter Unit			
●	Cleaned M.S. cover of the gravity filter unit to remove the dirt and dust	Yes/No	
●	Removed the top layer of coarse sand above the Netlon sheet	Yes/No	
●	Cleaned the sand	Yes/No	
●	Sieved the sand	Yes/No	
●	Re-laid the sand	Yes/No	
●	Checked & cleaned the U-PVC pipe along the periphery of the Gravity filter and its apertures	Yes/No	
Storage Tank			
●	Cleaned storage tank just before the monsoon	Yes/No	
●	Checked and repaired the air vent for any damages	Yes/No	
●	Checked net tide over the mouth of the air vent pipe on the storage tank	Yes/No	
●	Collected water sample for quality analyses for potability for the monthg of		
	o May	Yes/No	
	o June	Yes/No	
	o July	Yes/No	
	o August	Yes/No	
	o September	Yes/No	
	o October	Yes/No	
	o November	Yes/No	
	o December	Yes/No	
Existing Tube well (HP)			
●	Measured groundwater levels of production and recharge tube wells using Water level indicator on		
	o 1st and 15th of every month from May to October	Yes/No	
●	Collected sample from Pumping tube well for monitoring quality of water on every month from May to October and again in next May and June	Yes/No	

POST-MONSOON OPERATION AND MAINTENANCE-CHECK LIST

Conveyance system			**Date**
●	Inspected the pipes during monsoon and plugged leakages	Yes/No	
●	Immediately closed the first flush valve after the first rain	Yes/No	
●	Drained the stagnated water in the pipes after monsoon by opening the valve the gravity filter & storage tank	Yes/No	
Storage Tank			
●	Chlorinated the water @2 mg/litre in case of suspected contamination	Yes/No	
●	Collected water Sample for monitoring its potability for the month of:		
	o June	Yes/No	
	o July	Yes/No	
	o August	Yes/No	
	o September	Yes/No	
	o October	Yes/No	
	o November	Yes/No	
	o December	Yes/No	
Recharge tube well (Hand pump)			
●	Measured water level on		
	o July 1	Yes/No	
	o July 15	Yes/No	
	o Aug 1	Yes/No	
	o Aug 16	Yes/No	
	o Sept 1	Yes/No	
	o Sept 15	Yes/No	
	o Oct 1	Yes/No	
	o Oct 15	Yes/No	
●	Collected samples from pumping tube well for monitoring water quality		
	o July	Yes/No	
	o August	Yes/No	
	o September	Yes/No	
	o October	Yes/No	
	o November	Yes/No	
	o December	Yes/No	

Operation & Maintenance of Recharge system in GJB

1. **Roof catchment area**

Clean the roof and remove algae formation before the onset of the monsoon.

2. **Conveyance System**

- Leakage in the down pipes may be identified during downpour and the same should be plugged immediately.
- Clean the conveyance pipes just before the onset of monsoon.
- Clean all the manhole chambers just before the monsoon.

3. **Recharge tube well**

- Strictly ensure that no grease, oil or any other polluting material gets mixed with water that flows into the RWH system. This reduces the recharging capacity, in addition to contaminating the aquifer.
- Install Water meter on the drainpipe nearer to the tube well to monitor actual quantum of water recharged.

4. **Groundwater monitoring**

- Measure water levels in the production tube well using Water Level Indicator on fortnightly basis every month from May to October.
- Monitor Water Quality for all parameters of potability for samples taken from pumping tube well on every month from May to October.

5. **Overflow system**

- Clean the overflow chamber just before the monsoon.

PRE-MONSOON OPERATION & MAINTENANCE – CHECK LIST

Catchment area (Institute roof)			**Date**
●	Cleaned the terrace	Yes/No	
●	Checked the condition of iron net (*jali)* at the inlet of rainwater pipe	Yes/No	
●	Trimmed the hanging tree branches on the roof	Yes/No	
Conveyance system			
●	Cleaned the manhole chambers before the onset of monsoon	Yes/No	
●	Kept open the first flush valve to drain the first rain	Yes/No	
Recharge tube well			
●	Installed a Water meter device to measure quantity of rainwater recharged	Yes/No	
Production tube well			
●	Measured Water levels using Water level indicator for the month of:		
	o May	Yes/No	
	o May	Yes/No	
	o June	Yes/No	
	o June	Yes/No	
●	Collected water sample from the Pumping tube well for monitoring quality for the month of		
	o May	Yes/No	
	o June	Yes/No	
	o July	Yes/No	
	o August	Yes/No	
	o September	Yes/No	
	o October	Yes/No	

DURING AND POST MONSOON OPERATION AND MAINTENANCE – CHECK LIST

Conveyance system			
●	Inspected pipes during monsoon and leakages if any, repaired immediately	Yes/No	
●	Immediately closed the first rain flush valve after first rain	Yes/No	
●	Cleaned all manhole chambers after monsoon	Yes/No	
Recharge tube well			
●	Taken Water meter reading to find quantity of rainwater recharged on	Yes/No	
	o July 1	Yes/No	
	o July 15	Yes/No	
	o Aug 1	Yes/No	
	o Aug 16	Yes/No	
	o Sept 1	Yes/No	
	o Sept 15	Yes/No	
	o Oct 1	Yes/No	
	o Oct 15	Yes/No	
Pumping tube well			
●	Collected samples from pumping tube well for monitoring water quality on:	Yes/No	
	o July 15	Yes/No	
	o Aug 16	Yes/No	
	o Sept 15	Yes/No	
	o Oct 15	Yes/No	

Rainwater Harvesting for Reuse and Recharge in GJTI & GJB, Gandhinagar

Programme Implementation Calender - 2002

April	May	June	July	August	September	October	November	December
Submission of proposal to UNICEF, Gandhinagar	Data Collection Measurement of Roof area, Drainage Pipelines, Premises area, Rainwater downtake pipes.	Literature review from library and websites	Designing and cost estimation of Conveyance, Filters and Storage tank	Presentation of the design to GWSSB Engineers and UNICEF	Conveyance system - connecting existing raindrop pipes to the PVC pipes in GJTI	Earth excavation work for the storage tank in GJTI	Reinforcement work - binding steel rods and fixing shutters	Laying PCC for the bed of the water tank
Approval of the proposal	Analysis of the data			Exploring the possibility for a storage tank site for reuse system in GJB. Difficulty in locating the storage tank - Space constraint. Alternative options considered	Fixing the first flush valves to the newly laid PVC pipes in GJTI			Excavation for both the filter pits of size 3.5m x 3.5m x 3.5m
Agreement Signed				Steering committee meeting	Working Committee meeting			Laying PVC pipe at the bottom of the filter pit

Rainwater Harvesting for Reuse and Recharge in GJTI & GJB, Gandhinagar

Programme Implementation Calender - 2003

(continued)

January	February	March	April	May	June	July	August	September	October
Gravity filter construction for recharge in GJTI	Excavation work in GJB for laying conveyance pipeline	Re-laid earth material in GJTI and filling the earth in the adjoining area of RWH systems	Conveyance system in GJB - connecting the existing raindrop pipes to the newly laid PVC pipes	Fixing the contractor for the construction of tube well	Geophysical logging of the 200 ft. hole	Established the reuse system in GJTI - plumbing work, fixing electrical motor and installing the 300-litre HDPE tank	Prepared training materials	Preparation of the signages and caution Notice boards	Preparation of final report
Steering Committee meeting		Earth excavation work continued GJB	Tender notice for construction of tubewell in GJB	Tubewell construction - making 18" hole upto 200 ft.		Inaguaration of the RWH systems in GJTI and GJB	Circular to institutions and NGOs for sponsoring the staff for the training	Fixed the signages and the notice boards in both GJTI and GJB	Preparation of Process Document
		Steel grill fixed on the gravity filters GJTI		Fixing the first flush valves in GJB	Relaying of the excavated trench for the conveyance pipeline	Training to Engineers and Geologists of GWSSB (GJTI & GJB)	Conducted 2 Trainings	Conducted 2 Trainings	Collected water quality report from GJTI
					Fenced RWH systems in GJTI		Prepared Operation and Maintenance Manual for GJTI & GJB		