TECHNICAL REPORT

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GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION
CENTRAL GROUND WATER BOARD

REPORT ON FEASIBILITY OF ARTIFICIAL RECHARGE TO GROUNDWATER IN BAHADRABAD BLOCK, HARIDWAR DISTRICT, UTTARAKHAND

UTTARANCHAL REGION
DEHRADUN
JULY – 2024

Report on Feasibility of Artificial Recharge to Groundwater in Bahadrabad Block, Haridwar District, Uttarakhand

1. INTRODUCTION

Bahadrabad block is located in north eastern part of Haridwar district of Uttarakhand State. It covers an area of about 445.80 sq. km. It is located 11 km towards South from district head quarters Haridwar and 57 km from State capital Dehradun towards North. The Location map of Bahadrabad block is shown in **Fig. 1**. The block comprises of 114 villages. The famous holy Ganges originates from Gangotri Glacier, after travelling 300 kms in the Higher Himalayan Ranges and enters the plains in Bahadrabad block of Haridwar District.The location map is given as Fig 1.

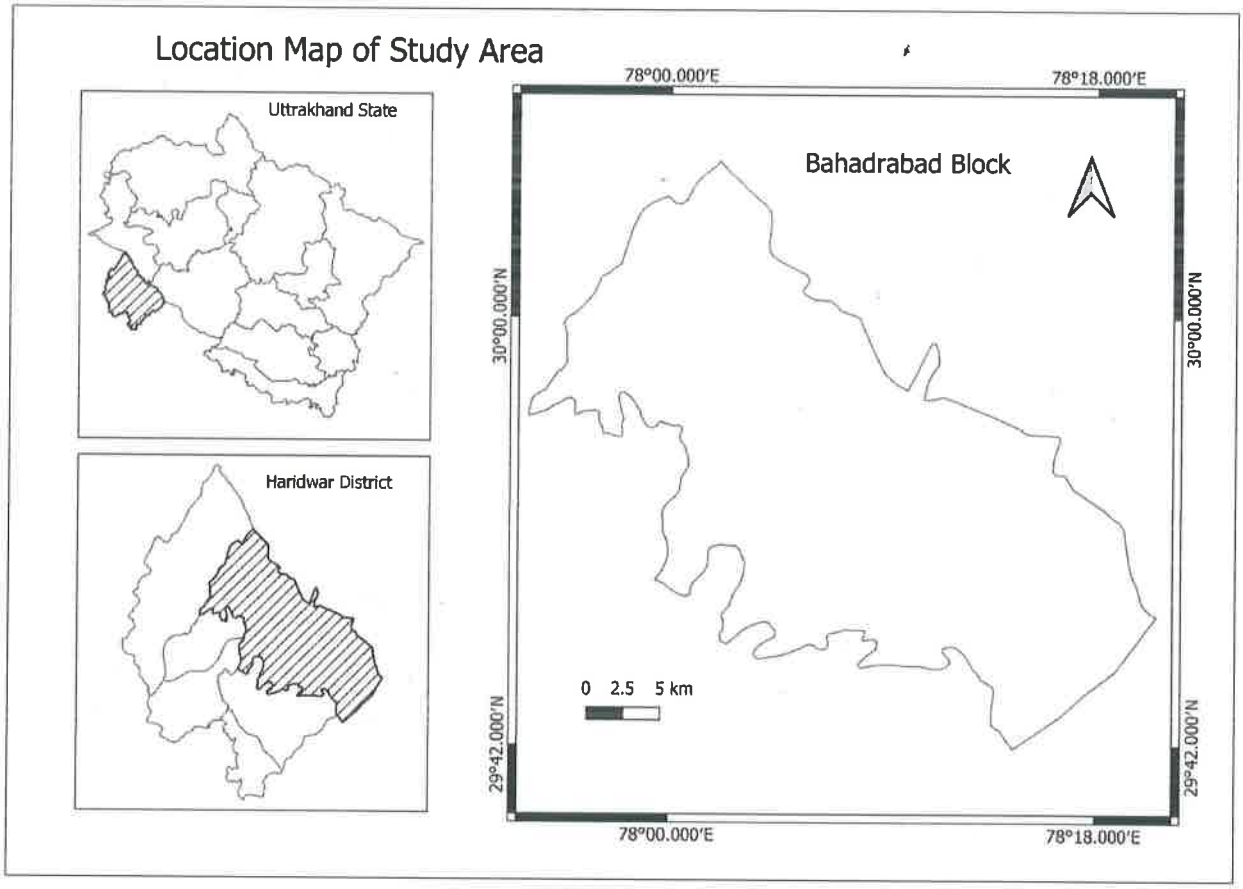


Fig 1: Location Map of Bahadrabad Block of Haridwar District

2. OBJECTIVE OF SCHEME

As per the instructions of the highe authorities, the Minor Irrigation Department is planning to construct Recharge Wells for artificial recharge to groundwater in the Bahadrabad block of Haridwar District. In this regard, a request has been received vide Letter No. 218/MI/Works/SARRA/2024-25 dated 21stJune, 2024 from Executive Engineer, Minor Irrigation, Haridwar District for feasibility of the artificial recharge to groundwater and depth of construction of the recharge structures.

The proposal is to construct suitable recharge structures (recharge wells/Shaft) so as to enhance the groundwater availability in the area by recharging the shallow aquifer using the rooftop rainwater Harvesting.

3. HYDROGEOLOGY

The hydrogeology of the area is mainly governed by its geology, physiography and hydrogeological properties of the geological formations.The northern and north-western part of the Bahadrabad block is covered by high steep hills of Himalayas called Siwalik Range.Hydrogeomorphologically, the area is classified into four geomorphic units Siwalik hill, Upper Piedmont (Bhabar), Lower Piedmont (Tarai) and flood plains (Fig 2).

Lower Siwalik rocks are not exposed in the Haridwar District. Middle Siwaliks predominantly consists of medium to fine grained multistoried sandstone. The groundwater prospects are poor in the rocks of Middle Siwaliks and they do not form goodaquifers. The Upper Piedmont zone bordering the Siwalik hill comprise of unconsolidated coarse material and provide an excellent hydrogeological setup for recharge and infiltration. The Bhabhar zone is predominantly formed by the boulders, pebbles and cobbles. The formation is highly porous and permeable and hence forms potential aquifers. Though it is difficult to drill through the boulder formation but the yield of the tubewells is very high. The tubewells may yield from 1000 to 3000 lpm. The streams disappear in the Bhabhar zone.Tarai is the wet

land occurring south of the Bhabhar zone. The springs reappear in the Tarai zo1, and give rise to swampy conditions which exists in the eastern part of the area. Tarai formation consists of fine to medium sand and silt with layers of clay. The formation is porous and permeable and forms aquifers with high potential. The tubewells yield between 1500 and 4000 lpm. Groundwater occurs under unconfined and confined conditions. Auto-flow conditions also exist.The Flood plains form the youngest geomorphic unit, including sandbars, channel bars and meander scars.

Hydrogeological map of Bahadrabad Block, Hardwar district, Uttarakhand

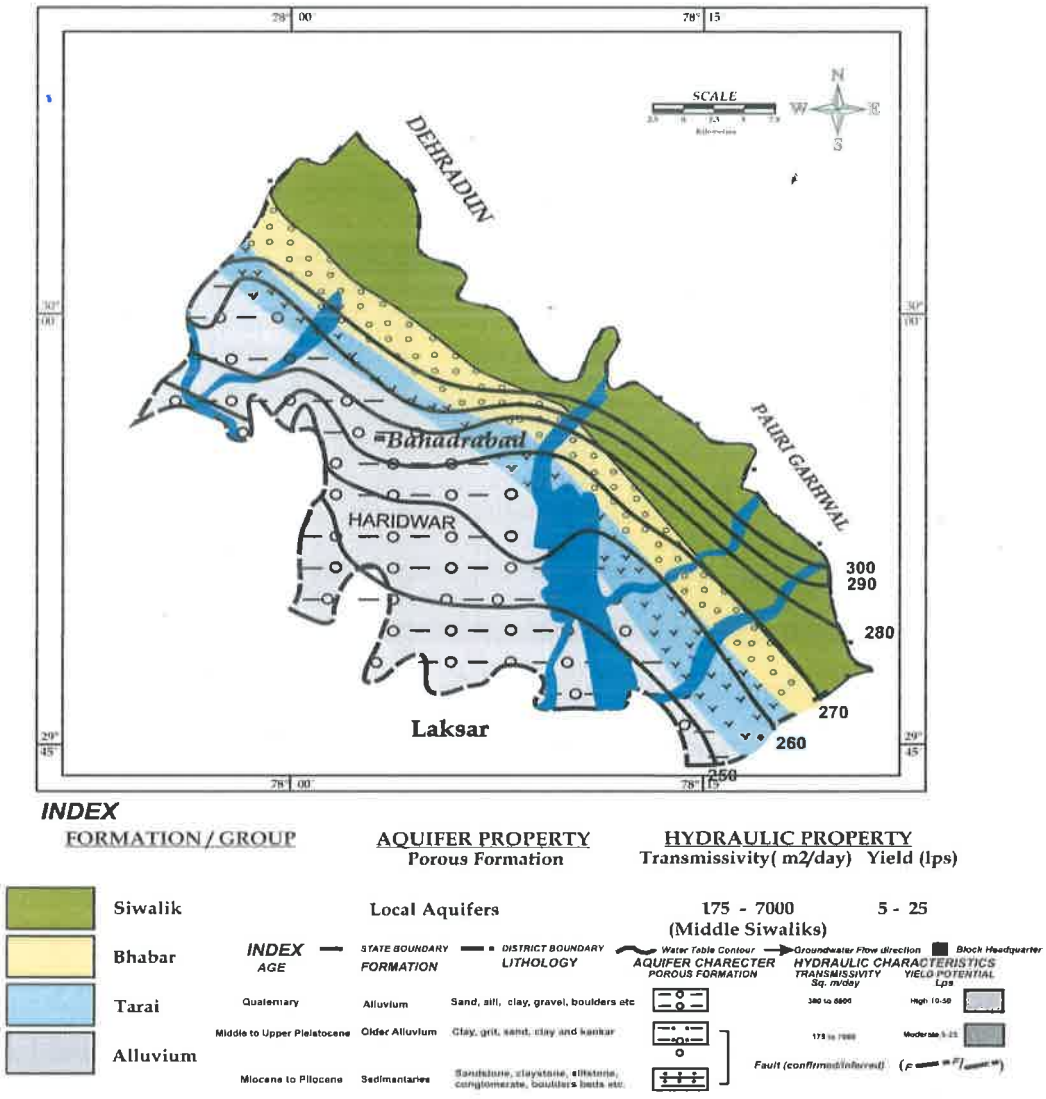


Fig 2: Hydrogeological Map of Bahadrabad Block, Haridwar District

Aquifer Geometry (3-Dimentional)

The Fence diagram (Fig 3) depicting the subsurface geological layers were prepared based on the available lithologs of the tube wells drilled by the Tubewell Construction Division, Roorkee and CGWB. An overview of the fence diagram shows that nature of alluvial sediment is complex and there is alternation of fine to coarse sediments from west to east. There exists a multi-tier aquifer system in the area separated by clay layers of considerable thickness. In the Tarai zone (alluvium), the saturated aquifer system is comprised of fine to medium-grained sand and gravels. In the bouldery formation (Bhabar zone) the aquifer group has been intervened by thin clay layers which at places are thick and mixed with boulders, cobbles and pebbles. The deposition of the coarser material all along the Ganges towards Haridwar town and also beyond up to Jwalapur and Mithiberi. Both phreatic and deep aquifers exist in the area.

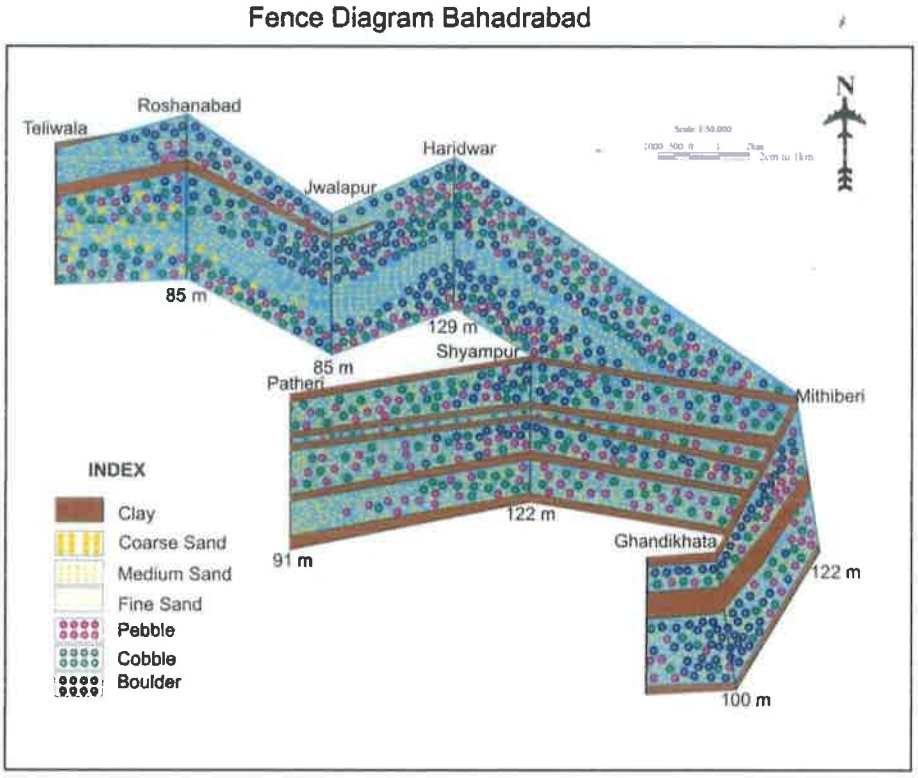


Fig 3: Fence Diagram of the Bahadrabad Block

The phreatic/shallow aquifer which approximately extends to the depth of around 25 m is of unconfined to semi-confined in nature. The deep aquifer is confined to semi

confined in nature and reported upto the depth of 110 metre. In Bhabar zo groundwater occurs under unconfined to semi-confined conditions. In Tarai zone groundwater occurs under both confined and unconfined conditions.

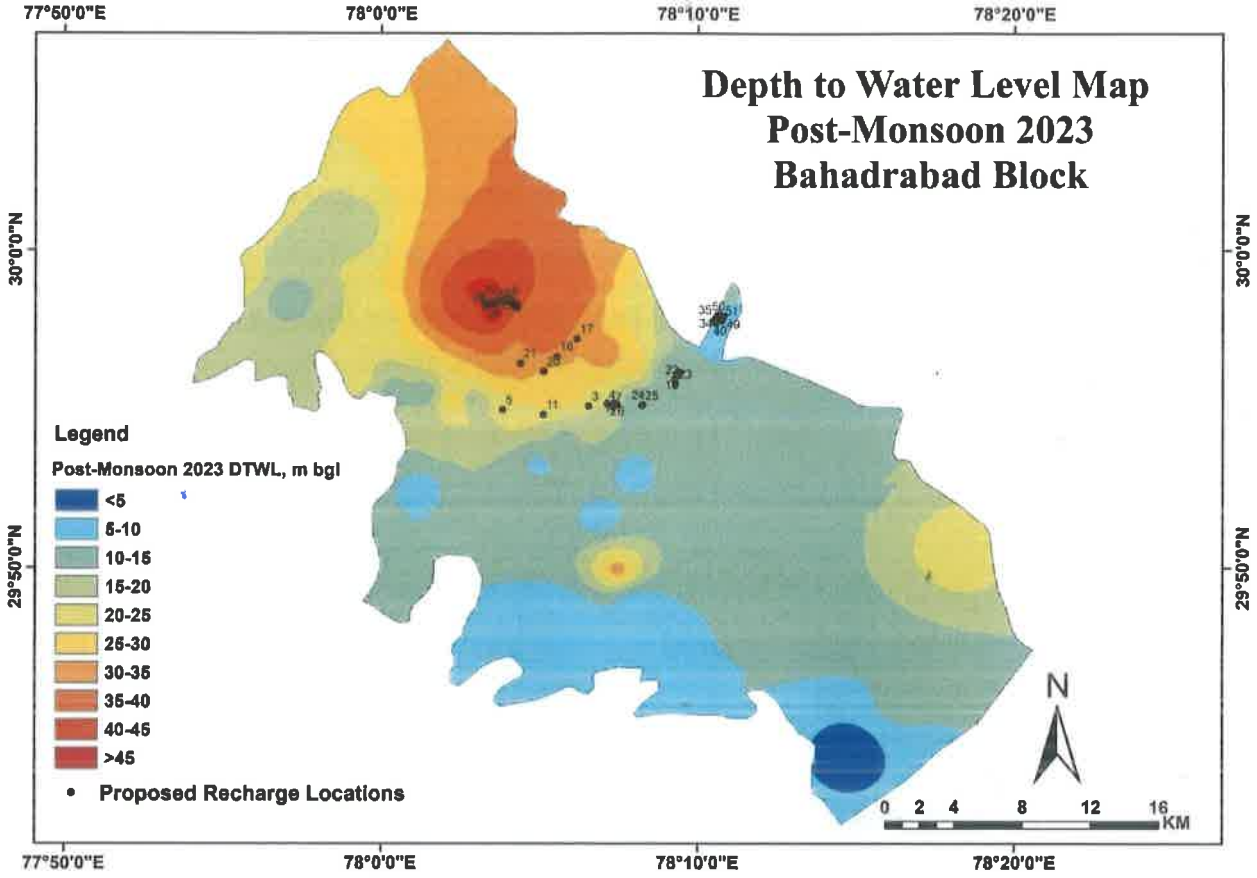


Fig 4: Depth to Water Level Map (Post-Monsoon, 2023) of Bahadrabad Block

Implementation of Measures for Artificial Recharge to Groundwater

Rainwater Harvesting is the technique of collection and storage of rainwater at surface or in sub-surface water bearing zones before it is lost as run off. Ever increasing population of the country and consequent increased use of ground water to meet the domestic, irrigation and industrial requirements, ground water resources were put under tremendous stress. This has resulted in lowering of water levels in large parts of the country, necessitating augmentation of ground water through artificial recharge by means of rainwater harvesting.

Area feasible for Artificial Recharge to Groundwater in Bahadrabad Block

The availability of source water and storage space is primary concern for preparation of any groundwater recharge plan. In Bahadrabad block of Haridwar district, the area suitable for ground water augmentation through artificial recharge has been demarcated based on the analysis of available data on depth to water level (2023). The entire area falling in foot hills of the Himalayas, i.e. Bhabar areas have been identified and considered suitable for groundwater recharge. The area in the vicinity of Ganga River i.e Active Flood plain of the River Ganga exhibits shallow groundwater levels and there is no need to construct any artificial recharge structure as water naturally gets infiltrated into the river and only those areas are to be prioritized for artificial recharge where post-monsoon water level is more than 5 m(Fig 4).

Recommendation

The following measures should be taken during implementation of artificial recharge to groundwater measures in Bahadrabad Block of Haridwar District.

- To avoid any water logging conditions, it is recommended that the **recharge schemes should only be taken up in those areas where water level is more than 5 m below ground level (post monsoon)**. Few of the locations provided by the Minor Irrigation are not feasible for artificial recharge to groundwater in Bahadrabad Block of Haridwar District (please refer to **Annexure- I- S.No 33-50**).
- The estimation of quantum of Rainfall Runoff yearly and hourly (peak rainfall) and recharge well design may be calculated as per the attachment (**Annexure-2**).
- As per the directions of Hon'ble NGT, the Ministry of Jal shakti, Govt of India has directed toavoid Rain Water Harvesting System for the purpose of Artificial Recharge in the vicinity of sewerage system components/ landfill sites etc where chances of contamination are high through mingling

of untreated sewerage water/domestic wastes.Therefore,**it is suggested that only non-polluted rainwater from the rooftops has to be diverted to recharge structure** through connection of downpipe. It is recommended that runoff water generated from open area and pavement should be avoided for use of artificial recharge as there may be chances for ground water contamination.

- There should be proper arrangements in place to prevent sewage water or contaminated water from paved area from mixing into run-off/ recharged water.
- The design of RWH should have provision to by-pass first rooftop harvested rainwater. Mixing of drain water with rooftop run off or with runoff from paved areas, where vehicle movement takes place, should be prevented.
- The water loaded with silt, chokes the gravel shrouded around the well and enters the sandy formations, thus reducing the permeability of the formations. Therefore, the water should be made silt free before it enters into the recharge well. For this purpose, water should be allowed to pass through the graded filter media or **Dual V wire screen** against the intake portion of recharge well.
- As per the prevailing hydrogeological conditions in Haridwar District, it is recommended to **drill the Recharge well upto 25 m below ground level for locations mentioned from S.No 1 to S.No 22 and upto 15 m below ground level for locations mentioned from S.No 23 to S.No 32.**
- Development of the Recharge well should be done with air compressor as it will help to clear the screen of the well and surrounding formation material, if ground water is encounter during construction of recharge well.
- The catchments should be neat and clean. The rooftop/terrace of the building spaces around the buildings should not be used for dumping of unwanted items and scrap material.

- The periodic removal of the material deposited on the surface is done by scraping the silt accumulated on top of the filter bed regularly.
- Precaution should be taken to avoid domestic waste water entering into the recharge structures.
- Put up sign boards mentioning that the campus of building is equipped with rainwater harvesting system which is being recharged to groundwater system. Mention the ill effects and health impacts if the storm water drains are not properly maintained. Educate the staff maintaining the storm water drains to keep the drains neat and clean.

Calculation of Amount of Rainwater from Rooftops for artificial recharge

The rain water available for groundwater recharging from the roof top catchment can be computed as follows:

$$A \times R \times C$$

A = Roof Top area

R= Quantum of Rainfall

C = Run-off Co-efficient Catchment

EXAMPLE: If Roof area is 150 sq. meter and rainfall is 1000 mm(1.00 m), the rain water harvesting potential & available rain water can be computed as follows:-

Total availability of Rain Water = A x R

$= 150\ m^2 \times 1.00\ m$

$= 150\ m^3$ or 1.5 Lakh Liter

Expected Recharge Potential = A x R x C

$= 150\ m^3 \times 0.80$

= 120 cubic meter or 120,000 Liter

The retention capacity of recharge structure has been calculated for rainfall intensity of 25 mm/hr .The dimension of the recharge pit as per the runoff generated for one hour of rainfall of 150 $m^2$of the rooftop area is furnished below.

Catchment type	Area (m^2)	Runoff Coefficient (C)	Rainfall Intensity (I)	Runoff (Q-CIA) (m^3/h)
Roof/Terrace Area	**150**	0.85	0.025	3.19

Q = run off (discharge) in cubic meters per hour

The recharge pit chamber may be divided into two chambers (i) Filtration Chamber and (ii) Recharge Chamber. The filter can be of two types i.e traditional or Synthetic (**Dual V wire screen**). The traditional filtration chamber (Graded Filter)consist of boulder, gravel/pebble and sand, each having thickness of 0.50 m. The filtration chamber is connected to the recharge chamber. The pipe of Recharge well inside the recharge filter should be slotted to allow/flow the filtered rainwater into the well. A jute bag/ plastic mesh may be wrapped around the newly slotted portion of wellin order to avoid any clogging or contamination. The calculation for total intake capacity of recharge pit with recharge well may be as follows-

Size of Filtration chamber: 2.00 (depth) x1(length) x 1(Breadth) m^3

Thickness of Filter Media: 0.5 m +0.5 m+0.5 m = **1.5** m

Free Board: **0.50** m

Considering average porosity of filter media is 30%

Intake capacity of Filter media: 2 x 1 x 1 x 0.3

= 0.60 m^3

Intake capacity of free board: 2 x 1 x 0.50

= 1.00 m^3

Total capacity of recharge pit filled with brick blast/boulders= 0.6 + 1.00= **1.60 m^3**

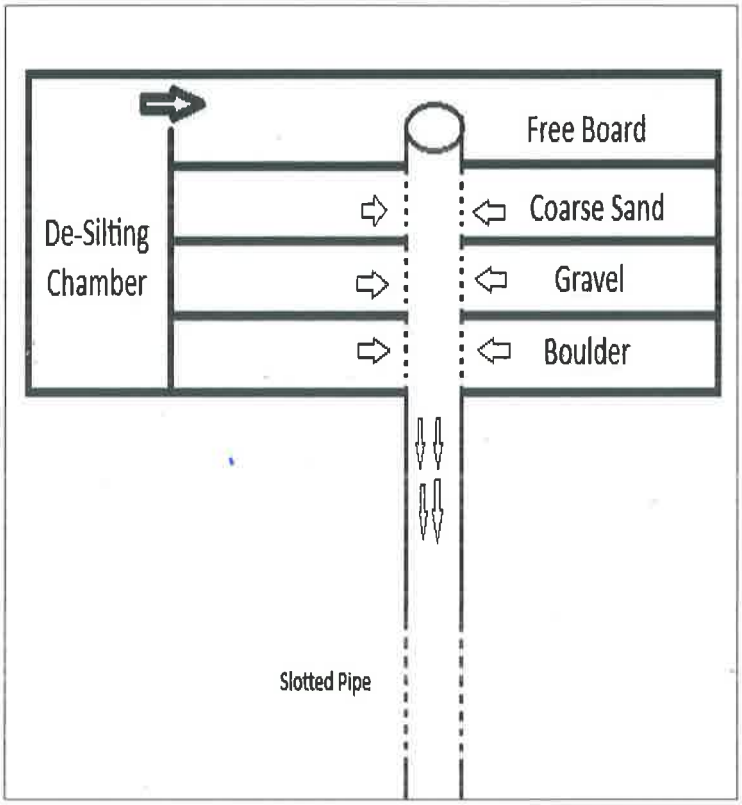
Considering discharge of tubewell in the area is 100 lpm or6.00 m^3 /hr

Recharge capacity of the tubewell is 25% of the discharge

Hence, intake capacity of recharge well is **1.5 m^3 / hr**

Total capacity of the structure = 1.6+1.5=3.10m^3 / hr

So, to accommodate the 3.10 m^3/hr of surface runoff generated through rooftop, one recharge structure is recommended for 150$m^2$of rooftop area. The design for artificial recharge to groundwater through rooftop rainwater harvesting is shown in **Fig. 5.**



(A) * figure not to scale

(B)

(C)

Fig 5: Rain Water Harvesting Design (A+B) for Artificial Recharge in Bahadrabad Block, Haridwar District and Dual V-Wire Screen Filter.

For any technical guidance, below-mentioned office may be contacted as and when required.

Regional Director, Central Ground Water Board, Ministry of Jal Shakti, Government of India, Uttaranchal Region, 419 – A, Kanwali Road, Balliwala, Dehradun – 248 001

ANNEXURE-2

हरिद्वार जनपद के शहरी क्षेत्र में रिचार्ज शाफ्ट की कार्ययोजनाः–

क्र0 सं0	योजना का नाम	Catchment area (Hect.)	Latitude	Longitude	Water Bearing Zones	Recharge Well Depth m bgl	CGWB Remarks
1	राजकीय नर्सिंग कॉलेज, रोशनाबाद।	0.50	29.9726	78.0579	>45	25	Suitable for Artificial Recharge
2	कार्यालय, मख्य चिकित्सा अधिकारी, रोशनाबाद, हरिद्वार।	0.65	29.9719	78.0596	>45	25	Suitable for Artificial Recharge
3	कार्यालय, जिला युवा कल्याण एवं प्रान्तीय रक्षक दल अधिकारी, रोशनाबाद, हरिद्वार।	0.70	29.9707	78.0549	>45	25	Suitable for Artificial Recharge
4	ग्रामीण निर्माण विभाग, कार्यालय रोशनाबाद के पास।	0.80	29.9731	78.0693	>45	25	Suitable for Artificial Recharge
5	जिला आर्युवेदिक कार्यालय परिसर, रोशनाबाद, हरिद्वार।	0.75	29.9734	78.0614	>45	25	Suitable for Artificial Recharge
6	किशोर सम्प्रेक्षण गृह, रोशनाबाद, हरिद्वार।	1.00	29.9736	78.0686	40-45	25	Suitable for Artificial Recharge
7	बाल सुधार गृह, रोशनाबाद, हरिद्वार।	0.85	29.9734	78.0671	40-45	25	Suitable for Artificial Recharge
8	भिक्षुक गृह, रोशनाबाद, हरिद्वार।	0.80	29.9743	78.0676	40-45	25	Surface Runoff water should be avoided for recharge
9	विकास भवन, रोशनाबाद, हरिद्वार।	0.70	29.9704	78.0704	40-45	25	Suitable for Artificial Recharge
10	एस0एस0पी कार्यालय, रोशनाबाद, हरिद्वार।	0.60	29.9716	78.0700	40-45	25	Suitable for Artificial Recharge
11	राजकीय सामुदायिक केन्द्र, पुल्ड आवास कॉलोनी, रोशनाबाद, हरिद्वार।	0.55	29.9735	78.0645	40-45	25	Surface Runoff water should be avoided for recharge
12	कार्यालय, मुख्य शिक्षा अधिकारी, रोशनाबाद, हरिद्वार।	0.50	29.9703	78.0707	40-45	25	Site already recommended to HRDA
13	श्रम न्यायालय, हरिद्वार	0.55	29.9723	78.0701	40-45	25	Suitable for Artificial Recharge
14	जवाहर नवोदय विद्यालय, रोशनाबाद, हरिद्वार।	0.75	29.9739	78.0537	40-45	25	Suitable for Artificial Recharge
15	उत्तराखण्ड जल संस्थान, रोशनाबाद, क्लैक्ट्रेट आवासीय पेयजल नलकूप सं0–01	0.50	29.9738	78.0650	40-45	25	Suitable for Artificial Recharge
16	पेयजल निगम परिसर, रोशनाबाद, हरिद्वार।	0.50	29.9731	78.0691	40-45	25	Suitable for Artificial Recharge
17	जिला पंचायत परिसर, रोशनाबाद, हरिद्वार।	0.55	29.9730	78.0696	40-45	25	Suitable for Artificial Recharge
18	केन्द्रीय विद्यालय, बी0एच0ई0एल0, हरिद्वार।	1.00	29.9442	78.0925	30-35	25	Suitable for Artificial Recharge
19	कन्वेंशन हॉल, बी0एच0ई0एल, हरिद्वार।	0.75	29.9536	78.1030	30-35	25	Suitable for Artificial Recharge
20	कोतवाली रानीपुर, हरिद्वार।	0.60	29.9365	78.0855	30-35	25	Suitable for Artificial Recharge
21	चिन्मई डिग्री कॉलेज, शिवालिक नगर,हरिद्वार।	0.65	29.9408	78.0732	30-35	25	Suitable for Artificial Recharge
22	प्राथमिक स्वास्थ्य केन्द्र परिसर,रोशनाबाद, हरिद्वार।	0.65	29.9725	78.0604	30-35	25	Surface Runoff water should be avoided for recharge
23	गुरूकुल कांगड़ी विश्वविद्यालय, जगजीतपुर, हरिद्वार (NBA)	0.60	29.2910	78.1220	20-25	15	Suitable for Artificial Recharge
24	गुरूकुल कांगड़ी विश्वविद्यालय, जगजीतपुर, हरिद्वार (Enviornment Science Dept.)	0.50	29.9197	78.1188	20-25	15	Suitable for Artificial Recharge
25	गुरूकुल कन्या परिसर, सीतापुर, ज्वालापुर, हरिद्वार।	0.55	29.9183	78.1091	20-25	15	Suitable for Artificial Recharge
26	गुरूकुल कांगड़ी विश्वविद्यालय, जगजीतपुर, हरिद्वार (अतिथि गृह)	0.65	29.9192	78.1241	20-25	15	Suitable for Artificial Recharge
27	गुरूकुल इंजीनियरिंग कॉलेज, हरिद्वार।	0.60	29.9164	78.0641	20-25	15	Suitable for Artificial Recharge
28	गुरूकुल कांगड़ी विश्वविद्यालय, जगजीतपुर, हरिद्वार (Block AB)	0.50	29.9202	78.1226	20-25	15	Suitable for Artificial Recharge
29	गुरूकुल कांगड़ी विश्वविद्यालय, जगजीतपुर, हरिद्वार (Hostel)	0.55	29.9179	78.1217	20-25	15	Suitable for Artificial Recharge
30	रामानन्द इंस्टीट्यूट, ज्वालापुर, हरिद्वार।	0.75	29.9139	78.0853	20-25	15	Suitable for Artificial Recharge
31	राजकीय आई0टी0आई, जगजीतपुर, हरिद्वार।	0.80	29.9190	78.1374	10-15	15	Suitable for Artificial Recharge
32	राजकीय आई0टी0आई, जगजीतपुर, हरिद्वार।	0.95	29.9187	78.1372	10-15	15	Suitable for Artificial Recharge

क्र० सं०	योजना का नाम	Catchment area (Hect.)	Latitude	Longitude	Water Bearing Zones	Recharge Well Depth m bgl	CGWB Remarks
33	बैरागी केम्प–1, हरिद्वार।	0.80	29.9362	78.1569	10-15	NA	Not Recommended as site falls in active flood plain of Ganga
34	बैरागी केम्प–2, हरिद्वार।	0.90	29.9346	78.1559	10-15	NA	Not Recommended as site falls in active flood plain of Ganga
35	बैरागी केम्प पार्किंग, हरिद्वार।	0.60	29.9323	78.1543	10-15	NA	Not Recommended as site falls in active flood plain of Ganga
36	बैरागी फिल्ड, हरिद्वार।	0.50	29.9300	78.1548	10-15	NA	Not Recommended as site falls in active flood plain of Ganga
37	पन्तद्वीप पार्किंग–1,हरिद्वार।	1.00	29.9654	78.1763	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
38	पन्तद्वीप पार्किंग–2,हरिद्वार।	1.00	29.9623	78.1760	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
39	पन्तद्वीप पार्किंग–3,हरिद्वार।	0.95	29.9658	78.1766	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
40	पन्तद्वीप पार्किंग–4,हरिद्वार।	0.85	29.9619	78.1757	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
41	पन्तद्वीप पार्किंग–5,हरिद्वार।	0.80	29.9637	78.1751	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
42	पन्तद्वीप पार्किंग–6,हरिद्वार।	1.00	29.9661	78.1770	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
43	पन्तद्वीप पार्किंग–7,हरिद्वार।	1.00	29.9662	78.1780	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
44	पन्तद्वीप पार्किंग–8,हरिद्वार।	0.75	29.9656	78.1784	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
45	पन्तद्वीप पार्किंग–9,हरिद्वार।	1.00	29.9636	78.1775	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
46	पन्तद्वीप पार्किंग–10,हरिद्वार।	0.95	29.9632	78.1770	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
47	पन्तद्वीप पार्किंग–11,हरिद्वार।	0.90	29.9698	78.0717	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
48	लालजी पार्किंग–1 हर की पौड़ी, हरिद्वार।	0.95	29.9655	78.1801	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
49	लालजी पार्किंग–2 हर की पौड़ी, हरिद्वार।	0.80	29.9655	78.1801	5-10	NA	Not Recommended as site falls in active flood plain of Ganga
50	लालजी पार्किंग–3 हर की पौड़ी, हरिद्वार।	0.90	29.9632	78.1792	5-10	NA	Not Recommended as site falls in active flood plain of Ganga

(8)

ANNEXURE-2

ESTIMATION OF QUANTUM OF RUNOFF AVAILABLE THROUGH RAIN WATER HARVESTING					
S.No.	Particulars	Area (Sq.m) (To be filled)	Rainfall (m) (To be filled)	Runoff Coefficient*	Quantum of Runoff available (Cum/Year)
	1	2	3	4	5 =(2*3*4)
1	Roof Top Area of building				
2	Road/Paved Area				
3	Open Land Area				
4	Green Belt Area				
5	Total Area (Sq.mt)				

* Ref: Manual of Artificial Recharge of Ground Water, (CGWB,2007)

ESTIMATION OF QUANTUM OF RUNOFF AVAILABLE PER HOUR AT PEAK RAINFALL					
S.No.	Particulars	Area (Sq.m) (To be filled)	Rainfall (m) (To be filled)	Runoff Coefficient*	Quantum of Runoff available (Cum/Hour)
	1	2	3	4	5 =(2*3*4)
1	Roof Top Area of building				
2	Road/Paved Area				
3	Open Land Area				
4	Green Belt Area				
5	Total Area (Sq.mt)				

Intake Capacity of Recharge well = 2lps or 7.2 cum/Hour

DESIGN OF RECHARGE STRUCTURE				
	Length/Radius	Breadth	Depth	Volume
Recharge Pit (Rectangular)				
Recharge Pit (Circular)				
Total Retention Capacity of Recharge Pit (Rectangular) in One Hour				
Total Retention Capacity of Recharge Pit (Circular) in One Hour				