TECHNICAL REPORT

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सत्यमेव जयते

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 NAINITAL DISTRICT, UTTARAKHAND

UTTARANCHAL REGION
DEHRADUN
AUGUST – 2024

1 INTRODUCTION

Nainital district comprises of eight blocks viz. Ramnagar, Haldwani, Bhimtal,Kotabagh, Dhari, Betalghat, Ramgah, Okhalkanda bounded by Khatima block of Udham SinghNagar district in the East, Almora district in the North. Since the major portion of Nainital district i.e., Bhimtal, Dhari, Kotabagh ,Ramgarh, Betalghat , Okhalkanda and some parts of Ramnagr and Haldwani blocks falls under hilly category (slope is more than 10%) so Aquifer management studies is not being carried out in these portion of the district. 1107.77 sq. Km lies between north latitudes 28°45′ and 29°10′ and east longitudes 79°50′ and 80°05′ and Ramnagar,Haldwani block of Nainital district and falls in parts of Survey of India toposheets 53K/15, 53O/3, 53O/7, 53O/8, 53O/11, 53O/12 & 53O/16.
Haldwani block of Nainital district Uttarakhand, India extends between 29°13’9.99”N to 29°21’6”N latitudes and 79°13’48”E to 79°59’23.99"E longitudes and encompasses an area of km² .The elevation of the town above mean sea level varies between 268m in the extreme south to 584m at the extreme north. Physiographically, Haldwani is settled at foothill region of KumaunHimalaya (also called as Bhabhar locally) made-upof quaternary deposits, i.e., coarse alluvium where the mountain streams debase and reappear in the nearby Indo-Gangetic plain. Climatically, the study area has sub-tropic climate conditions. The maximum temperature in the Haldwani block ranges from 38ºC to 40ºC and the minimum between 5°C and 10°C. The average annual rainfall approximately 1500 mm. The intensity of rainfall generally increases from north to South.

Ramnagarblock lies between the latitude North 29^0 13’31’’ to 29^0 34’ 8.29’’ and the longitudes East 78^0 50’ 32.6’’ to 79^0 18’ 51.89 and the average elevation of the town stands at 305 m above mean sea level which varies between 271 m in the extreme south and 419 m at the extreme north. Physio-graphically, Ramnagar is settled on a foothill region (locally called Bhabhar) made-up of quaternary deposits, i.e., coarse alluvium where the Mountain Rivers debauch and re-emerge in the adjacent Indo-Gangetic plain. Climatically, the block enjoys sub-tropical climatic conditions. The mean annual rainfall is 205 cm and the mean annual temperature varies from 15°C to 35°C. Only the months of May and June are hot though they are seldom oppressive.

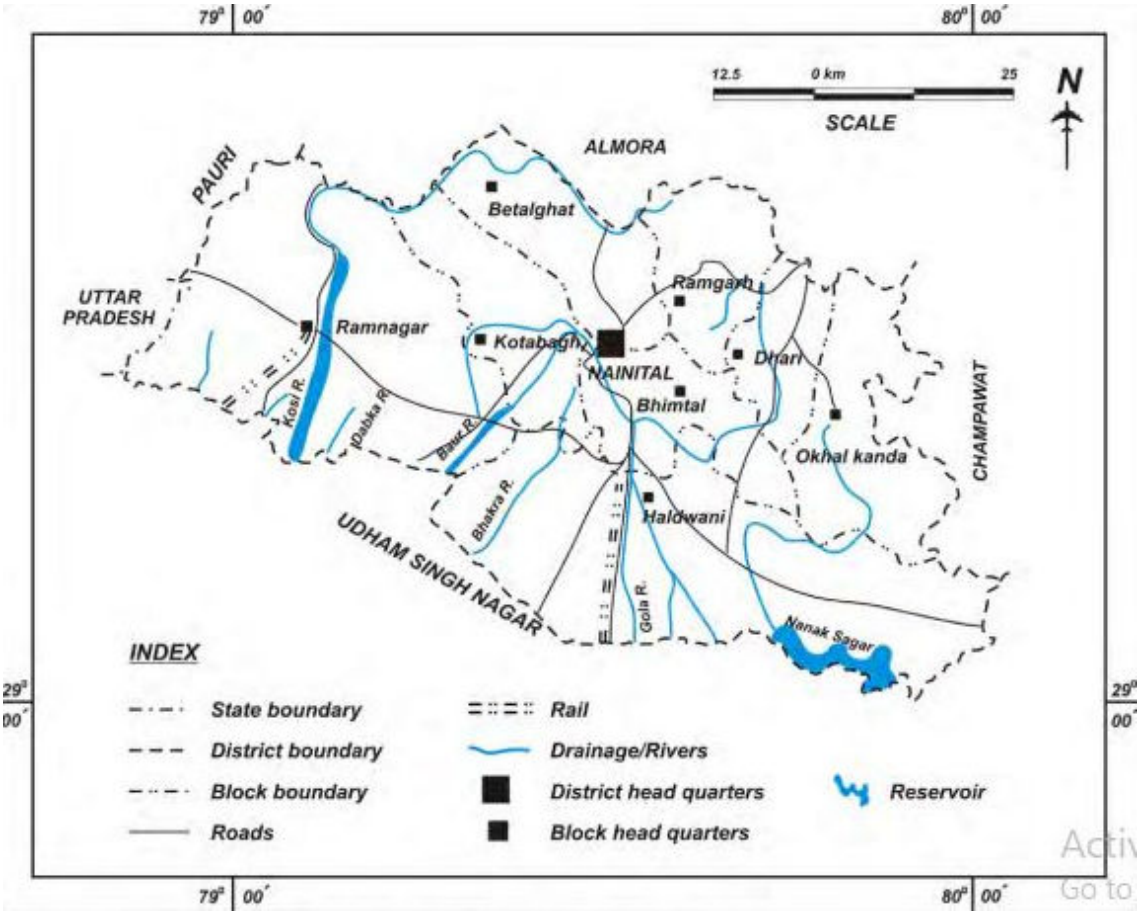

Figure 1.1 Administrative Map of Nainital District, Uttarakhand

2 OBJECTIVES OF THE SCHEME

In recent meetings of SARRA held on 19/06/2024 and 21/06/2024, the construction of recharge shafts across various locations in the Nainital district was proposed by the Chair.This initiative aimed to enhance groundwater levels by replenishing shallow aquifers through rooftop rainwater harvesting.

Following these discussions, a request was received from the Executive Engineer, Minor Irrigation, Dehradun, dated July 23, 2024 (Ref: 645/la.si./karya/SARRA/2024-25)- Annexure- 1 seeking a feasibility assessment for the proposed recharge structures and specific recommendations on their construction depth. CGWB has received a list of 23 proposed sites from Minor Irrigation for the construction of recharge shafts. Based on geo-locations provided, nearly all these sites are situated in Haldwani and Ramnagar block of the District.

3 HYDROGEOLOGY AND AQUIFER DISPOSITION

Nainital district can be classified into three broad geotectonic divisions namely, the Lesser Himalayas, the sub-Himalayas and the Piedmont alluvial plains. Each of these divisions is characterized by distinct rock types of varied geological age, structural trends, tectonic setting and geomorphic features.

2.1.1 Lesser Himalaya

The Lesser Himalayan formations occupy almost one third area of the district. These formations comprise dominantly of unfossiliferousmetasedimentary sequences along with low to medium grade metamorphics ranging in age from Precambrian to Palaeogene. The main rock types are granite, granodiorite, phyllites, slates, quartzites, schists and gneiss. The Krol and Blaini formations comprise mainly of sandstones, limestones and quartzites.

2.1.2 Outer Himalayan Foothill Zone

This zone can be classified into the Lower Siwaliks, Middle Siwaliks and the Upper Siwaliks.

a) **Lower Siwaliks:** The lower Siwaliks are characterised by hard, massive, grey to brownish grey sandstones interbedded with grey to maroon clays. They form the outermost zone in the Nainital Himalayas and occasionally exhibit local structural discontinuities. The dip is usually northwards.

b) **Middle Siwaliks:** The middle Siwaliks are characterised by massive light grey micaceous sandstones. They exhibit sporadic patterns of cementation at different stratigraphic intervals.

c) **Upper Siwaliks:** The Upper Siwaliks are constituted of pebbles, cobbles, boulders, conglomerates and clay lenses. The pebbles and boulders are mostly quartzitic. Thin lenses of grey to light green colour clays are common. Outcrops of upper Siwaliks are exposed in the western part between Kaladhungi and Ramnagar. Intermontane Valleys: Small (~ 25 km long and 10 km wide) intermontane valleys locally known as “Kota Doon” occur within the Sub-Himalayan Siwaliks trending in NNW-SSE direction. The epispastics mainly comprise of boulders, pebbles, cobbles, granules, sands & clays of varied composition.

2.1.3 Piedmont Alluvial Plains

This zone is broadly classified into the Bhabar and Tarai formations, which are separated by the spring line. Bhabar Formation: The formation is mainly comprised of poorly sorted unconsolidated sediments viz, cobbles boulders, gravel, pebbles, sand and silt with intervening clay layers. The lithological constituents are of heterogeneous nature viz., basic, acid and intermediate along with epiclastics and metamorphiclasts. Clay lenses are of limited extent. The belt exhibits NW-SE elongation. Its northern boundary has an abrupt structural contact (Main Boundary Thrust) with lower Siwaliks. The width of the belt is quite variable. The maximum width (about 21km) is in Haldwani – Kichha (Udham Singh Nagar) section. Tarai Formation: Tarai formation consists of sand, clay, silt, sandy clays and occasionally gravel. Clay beds predominate over sand beds. The northern limit of the belts is the spring line, separating it from Bhabar. The Tarai deposits represent the finer washes out material brought by the streams from the hilly tracts and are evenly sorte

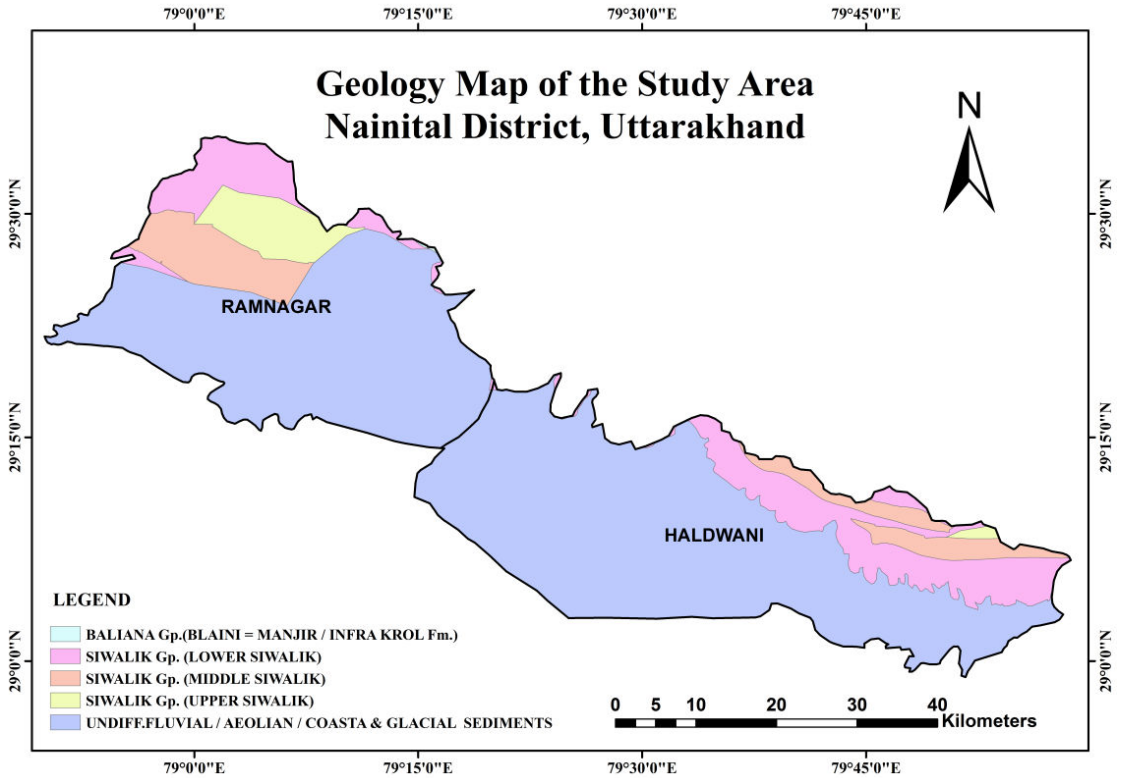

Fig. 1.2:Geology Map of Haldwani and Ramnagar block, Nainital district

The aquifer configuration in Haldwani and Ramnagar block, where the majority of recharge sites are proposed, has been delineated using a fence diagram and three-dimensional model (Fig: 1.3 and 1.4) based on CGWB exploration data. The diagram reveals the presence of a multi-tiered aquifer system that is primarily semi-confined to unconfined. These aquifers predominantly consist of boulders and gravel, indicating favorable conditions for groundwater recharge.

The potential zones exhibit promising yield prospects, as evidenced by significant discharge rates observed at key locations.

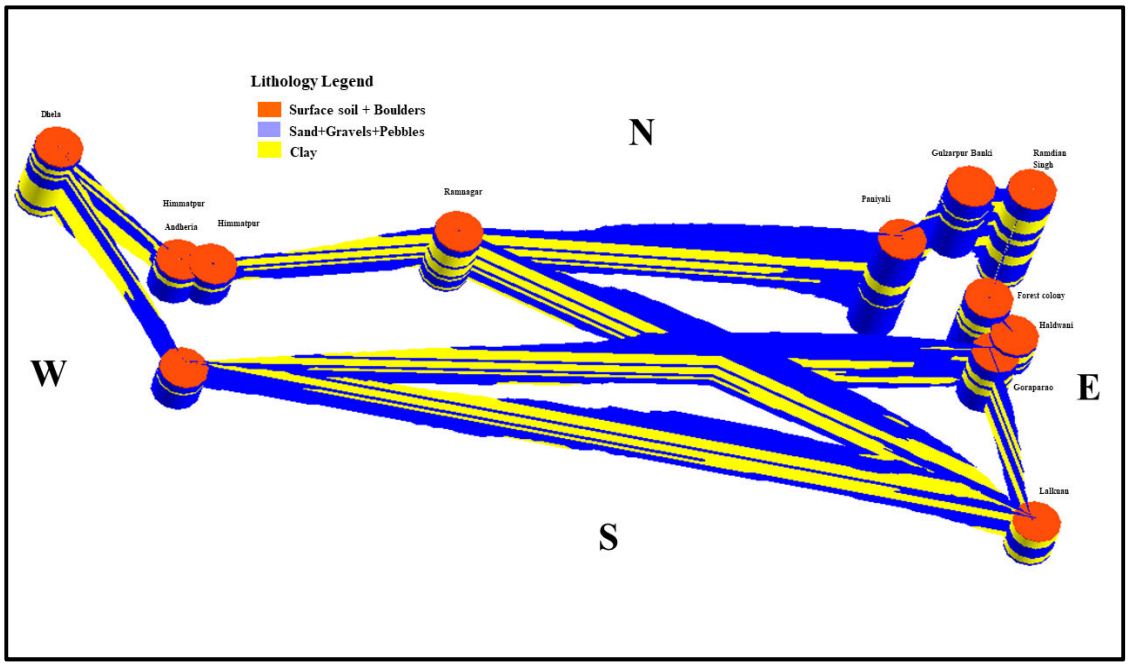

Fig. 1.3: Fence diagram Depicting Sub-surface lithological variation in Nainital district

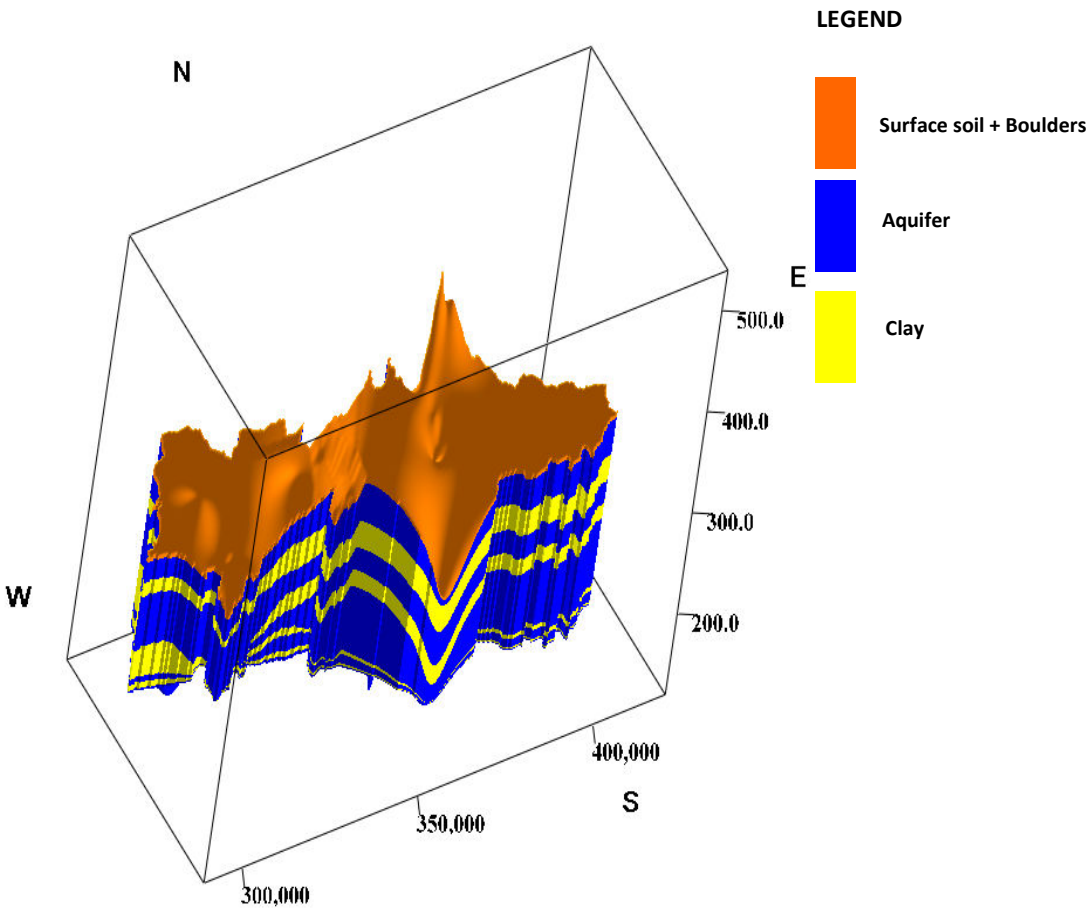

Fig. 1.4: Three-Dimensional aquifer disposition model of Nainital district

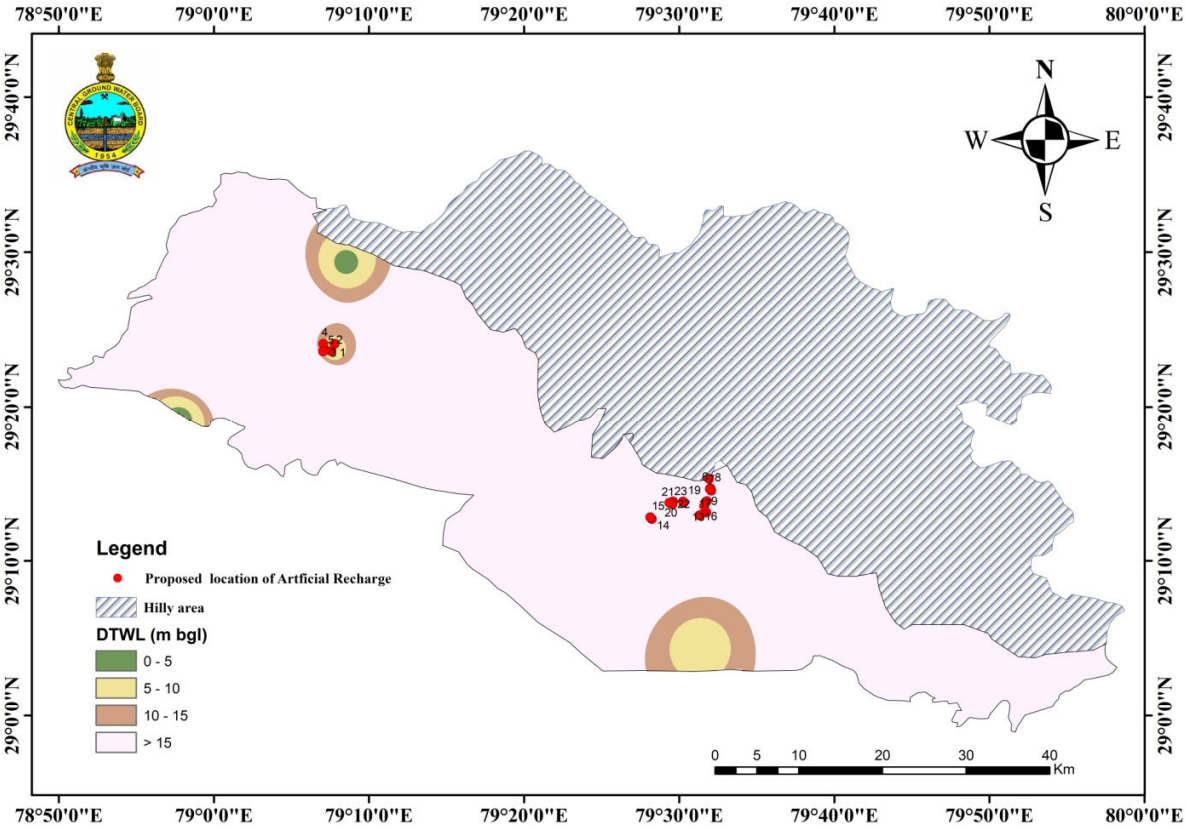

Fig. 1.5: Depth to Water Level Contour Map of Nainital district

4 IMPLEMENTATION OF MEASURES FOR ARTIFICIAL RECHARGE TO GROUNDWATERIN NAINITAL DISTRICT

Artificial recharge to groundwater through recharge shafts is a method aimed at replenishing depleted aquifers by directing surface runoff or collected rainwater into vertical shafts. These shafts are strategically positioned to facilitate efficient percolation of water into underlying aquifers, thus enhancing groundwater levels. Designed with filtration systems to maintain water quality, recharge shafts offer a sustainable solution to combat groundwater depletion. This approach not only improves water availability in regions prone to water scarcity but also contributes to environmental conservation by minimizing reliance on unsustainable water extraction practices. Effective implementation hinges on careful site selection based on hydrogeological conditions, ensuring optimal recharge rates and long-term water security benefits.

Based on the Post-monsoon groundwater level map (Fig. 1.5) of Nainital district for the year 2023, areas suitable for implementing recharge measures have been delineated, and corresponding depths for recharge structures have been specified (Annexure- 1). Adhering to established guidelines, it has been determined that groundwater recharge efforts are feasible in locations where post-monsoon water levels remain more than 5 meters. According to the water level contour map, all sites identified by the Minor Irrigation department for recharge initiatives meet this criterion, affirming their suitability for targeted interventions aimed at bolstering groundwater resources. This strategic alignment ensures that recharge efforts align with current hydrological conditions, maximizing effectiveness in sustainable water management practices across the district.

5 CALCULATION OF RAINFALL RUNOFF FROM ROOFTOP FOR ARTIFICIAL RECHARGE

The amount of rainwater harvested is computed as follows:

A * R * C

Where: A = Area of catchment (in sq.m), R = Rainfall (in m), C = Run off coefficient of catchment

As per the norms, the following coefficients are considered:

Sl No.	Type	Run off Coefficient
a	Rooftop	0.8
b	Road and Paved Area	0.6
c	Greenbelt	0.15

A model calculation for estimating the recharge potential of catchment area 1000 sq. m (0.1 hectare) comprising of rooftop and greenbelt has been demonstrated below:

Sl. No.	Catchment type	Area (sq. m)	Annual Rainfall (m)	Runoff Co-efficient	Volume (m^3/yr)
1	**2**	**3**	**4**	**5**	**6=3*4*5**
A	Rooftop	800	1.5	0.8	960
B	Greenbelt	200	1.5	0.15	45

The rainwater will be collected through piped drains and conveyed into rainwater harvesting system. Storm water drains should be designed for adequate size and slope such that there shall not be any flooding in the site. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. It shall be ensured that no wastewater shall enter into storm water drainage system. At terraces, mouth of the each drain should have wire mesh to restrict floating material. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. Provisions of first rain separator should be made at outlet of each drainpipe. The water will be stored in a storage tank and then recharged through recharge well.

Considering a peak rainfall event with intensity of rainfall 25 mm/ hr, the amount of water that will be generated as runoff in one hour is calculated as below:

Catchment type	Area (m^2)	Runoff Coefficient (C)	Rainfall Intensity (I) (m/hr)	Runoff Available (Q=CIA) (m^3/hr)
Rooftop Area	800	0.8	0.025	16
Greenbelt	200	0.15	0.025	0.75
			Total	**16.75**

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

Considering runoff generated from rooftop and greenbelt area, structures should be constructed to accommodate 16.75 m^3 of water. The storage cum recharge tanks are recommended of the dimensions 2m (Length) X 2 m (Breadth) X 1 m (Height) divided into 2 chambers- de-siltation chamber and recharge chamber. Effective storage area of each tank is **4 cubic meter**.

A recharge well (6 inch diameter) of **50 m bgl depth** is recommended to be drilled. The pipe should be perforated for infiltration of the rainwater. The perforated area should be covered with a mesh cloth which will act as a filter. This mesh cloth should be periodically changed for maintaining the structure. Dual V wire screen filters can also be used to reduce maintenance costs.

Considering the discharge of the tubewells in the area is around 1200 lpm, the recharge capacity of the well is assumed to be 25 % of the discharge. Hence the recharge capacity of the well will be 18 m^3/hr.

The total capacity of the structure = 4 m^3+ 18 m^3= 22 m^3

Hence, a storage tank along with one recharge well having slotted (1.58 mm) pipe of 12 m length is recommended to accommodate the total runoff during peak rainfall as shown in schematic diagram Fig 1.6

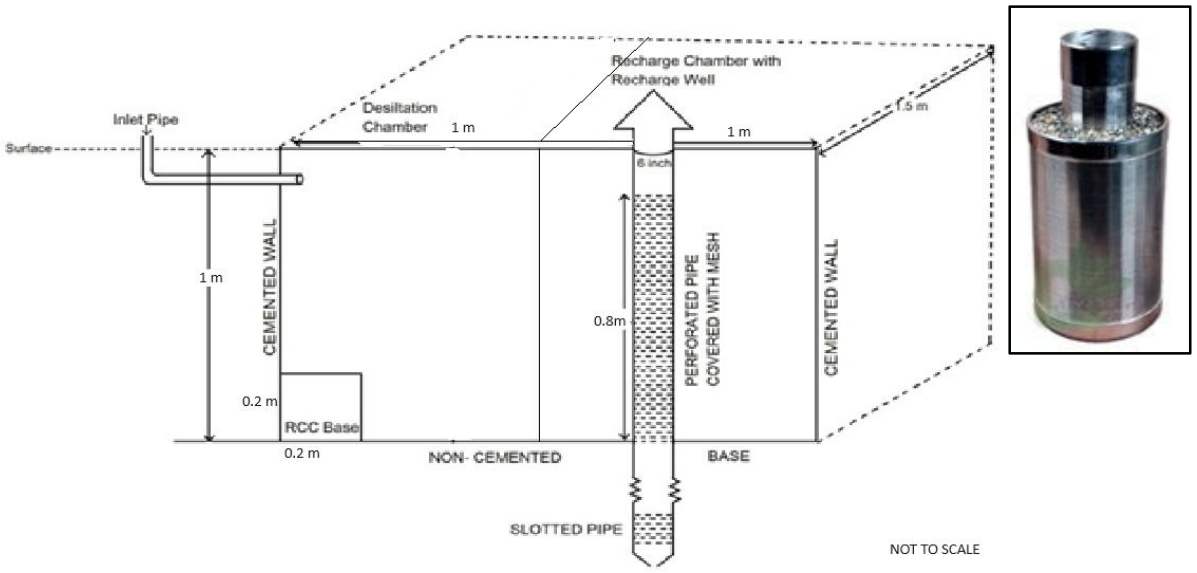

Fig 1.6: Schematic diagram of recharge well along with storage tank dual V wire screen filter displayed at the right

6 RECOMMENDATIONS

It is suggested that the Artificial Recharge schemes should only be taken up in those areas where water level is more than 5 m below ground level (post monsoon). The following measures should be taken during implementation of artificial recharge

- As per the directions of Hon'ble NGT, the Ministry of Jal Shakti, Govt. of India has directed to avoid 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.

- In areas prone to heavy traffic congestion, such as district transport offices, it is crucial to prevent rainfall runoff from open land. Similarly, at hospitals or clinics, it is essential that runoff from rooftop rainwater is directed exclusively to recharge structures to prevent groundwater contamination. These measures are vital for safeguarding groundwater quality in urban environments affected by high traffic and medical activities.
- 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 vehicular movement takes place, should be prevented.
- The water should be made silt free before it enters into the recharge well. For this purpose, first flush system should be installed in the RWH system.
- Development of the recharge well should be done with the air compressor as it will help to clear the screen of the well and surrounding formation material, if groundwater is encountered during construction of the recharge well.
- After development of the recharge well, intake capacity of the recharge well should be determined, using slug test.
- The catchments should be neat and clean. The rooftop/terrace of the building spaces should not be used for dumping of unwanted items and scrap material.
- Precaution should be taken to avoid domestic waste water entering into the recharge structures.
- Before the arrival of monsoon, the roof top as well as drains should be properly cleaned properly.
- Storage tank along with one recharge well having slotted (1.58 mm) pipe of 12 m length is recommended to accommodate the total runoff during peak rainfall.

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

Email: rdur-cgwb@nic.in

ANNEXURE 1

Sl. No.	Block	Proposed Location	Proposed Catchment area (Ha.)	Latitude	Longitude	WL Range during post monsoon 2024	Tentative Depth of Recharge Well	Remarks
1	रामनगर	पी0एन0जी0रा0स्ना0 महाविद्यालय रामनगर	1.0	29° 24' 06"	79° 07' 47"	~10	50	Suitable for Artificial Recharge
2	रामनगर	एम0पी0हिन्दू इण्टर कालेज रामनगर	1.0	29° 23' 37"	79° 07' 34"	~10	50	Suitable for Artificial Recharge
3	रामनगर	जी0जी0आई0 सी0 कालेज खताड़ी	1.0	29° 23' 42"	79° 07' 10"	~10	50	Suitable for Artificial Recharge
4	रामनगर	रा0ई0कालेज रामनगर	1.0	29° 24' 06"	79° 07' 03"	~10	50	Suitable for Artificial Recharge
5	रामनगर	खण्ड विकास अधिकारी रामनगर कार्या0	1.0	29° 23' 36"	79° 07' 02"	~10	50	Suitable for Artificial Recharge
6	हल्द्वानी	इन्स्परेशन सीनियर सेकेंडरी स्कूल	1.0	29°14'42.1"N	79°32'00.7"E	>15	50	Suitable for Artificial Recharge
7	हल्द्वानी	इन्स्परेशन बी.ऐड कॉलेज	1.0	29°14'32.5"N	79°32'03.8"E	>15	50	Suitable for Artificial Recharge
8	हल्द्वानी	संजय बलुटिया के खेत में तुलसी नगर दमुवाढुंगा	1.0	29°14'39.2"N	79°31'58.0"E	>15	50	Suitable for Artificial Recharge
9	हल्द्वानी	एस.डी.एम. कार्यालय हल्द्वानी	1.0	29°13'08"N	79°31'45"E	>15	50	Suitable for Artificial Recharge
10	हल्द्वानी	सेन्ट थेरैसा सिनियर सेकैन्डरी स्कूल	1.0	29°15'18.8"N	79°31'55.3"E	>15	50	Suitable for Artificial Recharge
11	हल्द्वानी	एम. बी. इण्टर कॉलेज हल्द्वानी 1	0.8	29°13'50"N	79°31'43"E	>15	50	Suitable for Artificial Recharge
12	हल्द्वानी	एम. बी. इण्टर कॉलेज हल्द्वानी 2	0.8	29°13'52"N	79°31'47"E	>15	50	Suitable for Artificial Recharge
13	हल्द्वानी	इन्द्रा प्रियादर्शिनी राजकीय बालिका कॉमर्स पी.जी कॉलेज	1.0	29°13'33.9"N	79°31'36.7"E	>15	50	Suitable for Artificial Recharge
14	हल्द्वानी	उत्तराखण्ड राज्य खाद्यय भण्डार ग्रह 1	0.8	29°12'42.5"N	79°28'14.0"E	>15	50	Suitable for Artificial Recharge
15	हल्द्वानी	उत्तराखण्ड राज्य खाद्यय भण्डार ग्रह 2	0.8	29°12'49.0"N	79°28'07.6"E	>15	50	Suitable for Artificial Recharge
16	हल्द्वानी	पी.एम. श्री राजकीय बालिका इण्टर कॉलेज 1	0.8	29°12'57.0"N	79°31'19.1"E	>15	50	Suitable for Artificial Recharge
17	हल्द्वानी	पी.एम. श्री राजकीय बालिका इण्टर कॉलेज 2	0.8	29°12'58.5"N	79°31'21.8"E	>15	50	Suitable for Artificial Recharge
18	हल्द्वानी	अमृत आश्रम ऊंचापुल	1.0	29°13'45.7"N	79°30'15.9"E	>15	50	Suitable for Artificial Recharge
19	हल्द्वानी	पी डी मेमोरियल स्कूल	1.0	29°13'50.3"N	79°30'14.9"E	>15	50	Suitable for Artificial Recharge
20	हल्द्वानी	सरस्वती अकाडमी	1.0	29°13'51"N	79°29'36"E	>15	50	Suitable for Artificial Recharge
21	हल्द्वानी	सिंदुर बैंकट हॉल	0.8	29°13'43.1"N	79°29'28.2"E	>15	50	Suitable for Artificial Recharge
22	हल्द्वानी	मेपेल वुड स्कूल ऊंचापुल	0.8	29°13'39.1"N	79°29'33.5"E	>15	50	Suitable for Artificial Recharge
23	हल्द्वानी	लघु सिंचाई उपखण्ड हल्द्वानी	0.6	29°13'46.0"N	79°29'21.9"E	>15	50	Suitable for Artificial Recharge