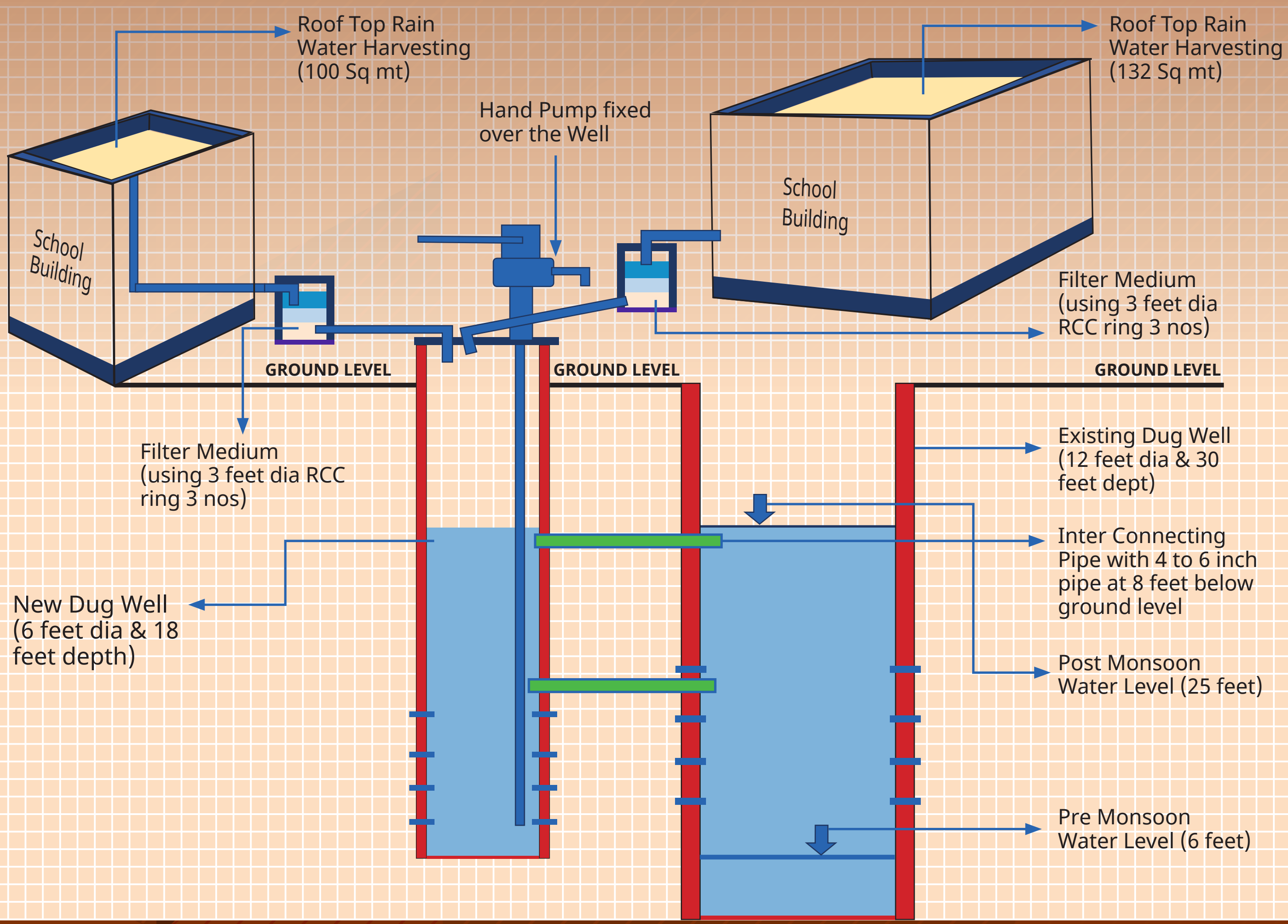
GUIDING NOTE

WaterAid

ARTIFICIAL RECHARGE OF DUG WELL THROUGH ROOF-TOP RAIN WATER HARVESTING



Guiding Note: Dug Well Artificial Recharge

This is a guiding note on how to implement dug well recharge models in our operational areas. This document tries to answer some frequently asked questions regarding dug well recharge model. Please note that the guide tells us about artificial recharging of dug wells through water collected from only roof-top (Not from any other surface).

Introduction

Recharge of groundwater is a normal process. A part of the rainfall, that falls over land surface, flows over the land – called run off or overland flow. Another part of the rainfall evaporates back to atmosphere and the 3rd component infiltrates into soil. The infiltrated water percolates downward and also laterally, under the force of gravity and ultimately joins the water table and recharge the aquifer. Besides, natural recharge also takes place from stored or flowing surface water - like rivers, tanks, lakes etc, provided the water table of the area lies below the bottom of that. Such recharge is a part of the water cycle and helps in natural replenishment of groundwater resources in aquifers.

The term Artificial Recharge refers to transfer of surface water to the aquifer by human interference. The natural process of recharge is accelerated by enhancing the rate of infiltration and percolation by way of manmade facility. It can be achieved by either way or combination of both; (i) Extending the availability of water over the surface and (ii) enhancing the rate of movement of groundwater to soil and vadose zone.

Need of Recharge

Natural recharge of groundwater is a slow process and often it can't keep pace with the rate and volume of groundwater extracted in an area. In such cases over-exploitation of groundwater resources occurs, resulting in declining water levels, desaturation of aquifers, dwindling well yields or even drying up of wells. Besides, there are reports of increasing salinity (in non-command areas) and also other geogenic contamination like fluoride and arsenic (Mukherjee et al 2015), which, according to many researchers are connected to over-exploitation of groundwater resource.

Artificial Recharge aims to augment the natural replenishment of groundwater through suitable civil construction. It is considered as one of the most important supply side interventions, to combat over exploitation of resource (Saha et al 2017). It has also proven its efficacy in reducing contamination load in groundwater and improving salinity. Occurrence of rainfall in India is mostly limited to about three months in a year. Natural recharge of groundwater is also restricted mainly to this part of a year. Artificial Recharge (coupled with Rainwater Harvesting) aims in extending the recharge period in post monsoon months, resulting in enhancing sustainability of groundwater resources during lean season.

Though the main objective of Artificial Recharge is to replenish depleted groundwater resources and bring sustainability to its utilization, there are other benefits like;

1. Control sea water ingress in coastal aquifer because of fresh water extraction
2. Recovery of oil from partially depleted oil fields.
3. To control land subsidence.
4. Improve quality of groundwater, reduce load of contamination. v. Create strategic resource for emergency use.

Dug Well Recharge

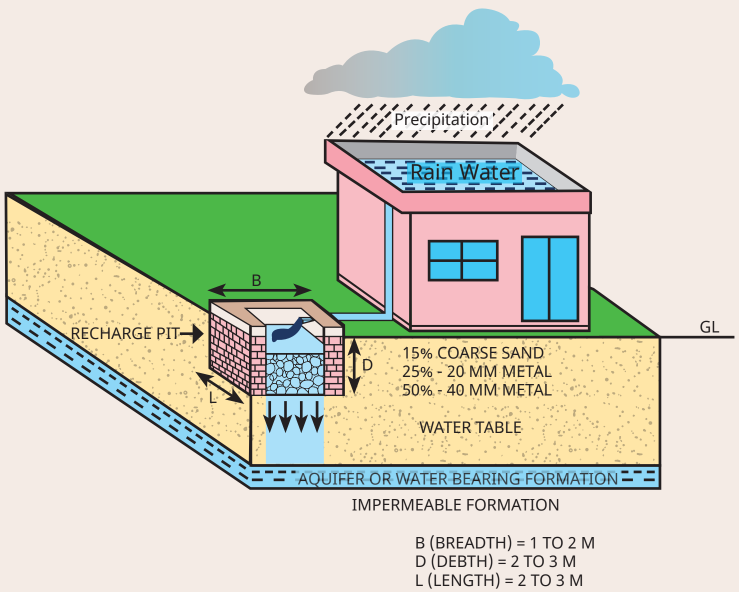
Technically this type of recharge structure comes under the category “Gravity head recharge well” In areas where considerable desaturation of aquifers has taken place and water level has declined - resulting in drying up of dug wells and shallow wells, such technique is suitable. Existing defunct dug well can be used, after proper cleaning and rehabilitation as a cost-effective mechanism.

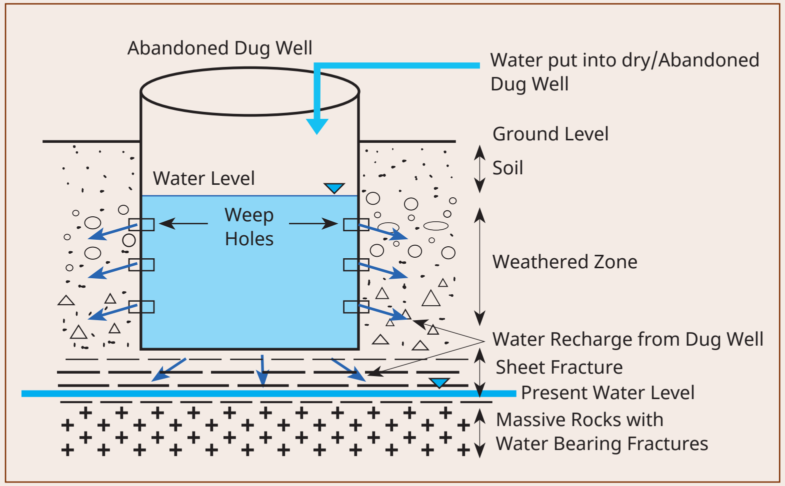
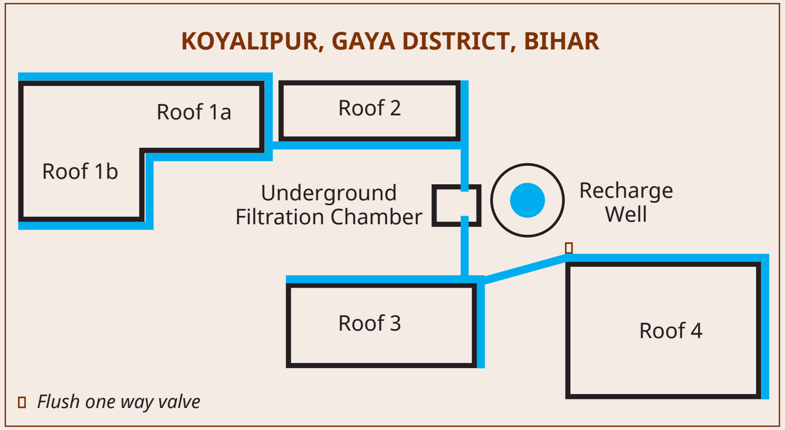
Abandoned due to deep water level can be used for Artificial Recharge. The Source Water can be overland flow or stream flow or even roof water, which requires to be desilted and filtrated and then put into dug well for recharge. The water will primarily recharge through the bottom of the dug well. In addition, “weep holes” can be created on the wall of the dug well (Brick or concrete lines) which will also facilitate recharge under the hydraulic head created by the Source Water put into the dug well.

Where should this be attempted?

- It may not always be possible to implement artificial recharge projects in the entire area even though the need is established, due to various constraints.
- Prioritization of areas is normally done through post-monsoon depth to water level which can indicate long-term depleting trend of water level (Can be understood by consultation with community proximate to open well).
- The geography needs to be primarily in “Hard Rock” area. However, this can also be tried in soft-rock areas (if the need is established though assessment – Please check the following table).
- The prime reason behind the artificial recharge has to be the village/ site should be requiring artificial recharge (Based on need assessment).

Step Wise Actions Needed

SL	Steps	Indicators	Actions	Template/ Reference
1.	Need assessment	Deep WL/ declining WL *Peak monsoon water level > 2mbgl*	1. Measurement of water levels. 2. Water level data from State CGWB reports. 3. Water level trend analyses	1. Use measuring tape or water level recorder 2. To understand more visit: http://cgwb.gov.in/GW-data-access.html https://www.indiawris.gov.in/wris/#/DataDownload
2.	Type of aquifers	Soft rock aquifer (alluvial/ aeolian) Hard rock aquifer	1. Field visits, look into road section or examine unlined dug well (not in line). 2. GSI/ SOI/CGWB maps & reports	For more details, visit: https://bhukosh.gsi.gov.in/Bhukosh/Public https://surveyofindia.gov.in/pages/open-series-map-osm- http://cgwb.gov.in/Ann-Reports.html
3.	Identifying suitable dug wells	1. Dug well remain dry round the year 2. Average monthly water level >2mbgl during monsoon period. 3. Abandoned dug well 4. Dug well should not be located in a submerged or water-logged area 5. Should not be located very close to stream/ river 6. Dug well should not be prone to contamination	1. Field visits and physical examination of the dug well 2. Measure/ enquire water level in monsoon months. 3. Whether dug well can be cleaned and rehabilitated with reasonable cost. 4. Whether owner agrees in case of private well? 5. Sanitary risk assessment of dug well.	 **Figure 1:** Roof top rain water harvesting

SL	Steps	Indicators	Actions	Template/ Reference
				 **Figure 2:** Mechanism of recharge in a dry dug well in hard rock areas
4.	Availability of roofs nearby dug well	Type of roof can be considered: GI sheet/ asbestos/ concrete. Condition of the roof (Is there any breakage or leakage)	• Number of roofs and total roof area can be connected to dug well with reasonable cost. • Requirement of rain water pipes, gutter. And other fixtures. • Investment needed to repair/ clean the roofs • Whether owner agrees to extend their roofs and cleaning	 **Figure 3:** Total roof area for recharge well 378.8 m², Koylipur, Gaya Minimum roof area required (single or cumulative): 50m²

SL	Steps	Indicators	Actions	Template/ Reference
5.	Cost effective design of the structure	Optimise sourcing of water (roof-top) Filter chamber size Recharge by the dug well	• Renovating/ treatment required for the dug well • Work out total roof area • Total length of pipe/ accessories needed. • Size of the filter chamber and volume of filter material needed. • Arrangement for drain out the first flush from the roof. • Diversion of excess water from roof during high rainfall event.	**Annexure 1** ***Example: Yapaldini hamlet****, beside main road junction,* ***Raichur dist, Karnataka*** ***Hard Rock Aquifer*** *Depth: 8 mbgl, Dia. 12 m* *Three roofs, total area: 507 m*^{2} *An annual rainfall (20 yrs): 621 mm* *Roof runoff coefficient: 0.8* *Volume of recharge = Roof area x av. Annual rainfall x runoff coefficient+* *252 m*^{3}*/year*
6.	Estimating cost of the structure	Cost should not be too high (*not more than INR 1.2 Lakh/ structure*)	• Cost of cleaning/ repairing of the dug well • Repair/ treatment of roof • Cost of pipes and accessories • Cost of digging and brickwork for filter chamber • Cost of filter material • Cost of hand pump if to be fitted on the well • Cost of monitoring	**Annexure 2** ***Example: Rajapadar hamlet, Nuapada dist., Odisha*** *Hard rock aquifer* *Roof treatment: Rs 46,133* *Desilting of well: Rs 6,800* *Dugwell renovate/ parapet repair, slab cover: Rs 24712* *Filter chamber and media: Rs 3,500* *Rain waterpipes, connecting PVC pipes: Rs 2,300* *Cost of hand pump fitted on dug well: Rs 7,500* *Misc. Expenditure/ painting: Rs 5,000*
7.	Maintenance of structure	Wear and tear of the entire structure and roof-top	• Cleaning of roof before monsoon. • Repair of roof if leakage • Replacement of pipes/ elbows etc. if leaking	

SL	Steps	Indicators	Actions	Template/ Reference
			• Cleaning of pipes/ de-weeding of sand layer in recharge pit before every monsoon • Replace the entire top sand layer in each 5 years (in recharge pit)	Annual maintenance cost should not be >5% of the total cost
8.	Funding for construction and maintenance	Source of funding	• Raise fund from organisation • Arrange through Govt. scheme (MGNREGA/ CGWB/ SGWB/ FC fund with GP) • Community funding	
9	Impact monitoring	Water level rise Better water availability in the dug well/ handpumps/ borewells (around recharge structure) Improvement in water quality	• Community mobilisation/ participation • Select observation wells • Pre and Post Monsoon Water Level measurement • Measurement of post monsoon EC	**Table 1:** Monitoring of water levels at Janghamunda Nuapada dist. (The table below is monthly data. But no need to follow the frequency as per table. Its just an indicative table to guide)

Date	OW 1	OW I2	OW 3	OW 4	OW 5	OW 6
Distance in m	50	100	140	200	500	500
24-12-2020	3.96	3.35	3.05	2.44	2.74	3.05
28-01-2021	4.15	3.47	3.26	2.47	3.02	3.26
10-02-2021	4.36	3.66	3.35	2.74	3.35	3.35
15-03-2021	4.27	3.96	3.51	3.05	3.66	3.66
15-04-2021	4.57	4.27	3.96	3.66	3.96	3.96
15-05-2021	5.67	4.63	5.09	4.11	4.21	5.79
15-06-2021	5.49	4.42	4.57	3.66	4.11	5.79
15-07-2021	5.18	3.81	3.66	3.20	3.35	4.88
16-08-2021	4.27	2.74	2.80	2.83	2.74	3.96
15-09-2021	3.35	2.44	2.13	2.19	2.13	2.74
15-10-2021	2.19	2.29	1.83	1.52	1.55	2.19
15-11-2021	2.96	2.74	1.98	1.83	2.23	3.05
15-12-2021	3.26	2.99	2.38	2.13	2.44	3.35
15-01-2022	3.66	3.05	2.90	2.59	2.74	3.66
15-02-2022	3.96	3.29	3.14	2.93	3.11	4.05

Artificial Recharge through Roof-top "Rain Water Harvesting" using normal/ abandoned dug wells: Guideline

A. Selection of locations/ sites	The geography needs to be primarily in "Hard Rock" area. However, this can also be tried in soft-rock areas. The prime reason behind the artificial recharge has to be the village/ site should be requiring artificial recharge (Based on need assessment).
B. Cluster of several dug-wells in a habitation	It's always better to go for a cluster of 3-4 villages for greater result. However, the need assessment along with availability of well and roof area will tell whether to go for a cluster wise approach or can be selective ones.
C. Minimum scale	A minimum of 10 abandoned dug wells is to be identified from each village. The identified abandoned dug wells need to be in close vicinity so that cross linking is possible.
D. Whether all dug wells are suitable for recharge	1. Look for abandoned dug wells. Dug wells which are not under regular use are also suitable. 2. Dug wells located within or near residential area are appropriate as roofs are required 3. Dug wells located in swampy/depressed areas/close to stream/ river may not be considered 4. Best to be taken up: The well that is dried up because of lowering of water levels.
E. Different component of the structure	1. Dug well for recharge 2. Suitable roof: concrete, GI Sheet, Asbestos 3. Arrangement of pipes and related fixers 4. Filter chamber and filter material 5. Observation wells for monitoring
F. Minimum size of the roof for a recharge structure	Cumulative roof area: 50m^2 for rainfall>1000 mm 75m^2 for rainfall 500-1000mm 100m^2 for rainfall <500mm
G. Minimum number of observation wells for each dug-well?	**Soft Rock areas:** 4-6 OW at different directions and at different distances, up to 200 m. **Hard Rock areas:** 5-7 OW at different directions and at different distances, up to 150 m
H. If it is a cluster of dug wells that will be recharged then how many observation wells?	**Soft Rock areas:** 6-8 OW at different directions and at different distances, up to 300 m. **Hard Rock areas: 6-8**-10 OW at different directions and at different distances, up to 250 m

I. What information needs to be collected in advance (Before recharge intervention)?	1. Whether suitable dug well is available for recharge and for monitoring. 2. Roof area, and condition of the roof, which can be connected to the well considering distance and slope. 3. Broad lithological character so that a broad hydraulic property of aquifers. *In better soil permeable areas (soft rock), roof area can be bigger than the low permeable areas (hard rock)* 4. Normal annual rainfall and normal monsoon rainfall (at least for 20 years) 5. Location of the dug well (refer point D of this table) 6. Depth to water level during pre-monsoon 7. Depth to water level during peak monsoon 8. 10 years long term water level data (from CGWB/ WRIS/ State Govt)
J. Tentative cost/m^3 recharge	Preferably between INR 10 to 30/m^3
K. What information needs to be collected in subsequently (post construction of recharge structure)?	1. Monitoring of water levels from observation wells, pre and post-monsoon for 3 years for 10 years (with once in a year) 2. Monitoring of electrical conductivity (EC) from observation wells, pre- and post-monsoon for 2 years 3. Improvement in water availability within 150/200 m radius, during pre and post monsoon by community survey for 2 yrs.
L. In case of roof-rain water being used for recharge what should be the minimum filtration mechanism?	A sand bed filter is must. The size of the filter material should be upward fining (the grain size decreasing upward). No chlorination needed; however, a 10 cm thick charcoal layer be placed to get rid of the quality issue. The bottom of the pit should remain open. (Annexure 1)
M. Does the roof water need any treatment	No treatment is needed. The roof should be cleaned thoroughly before the onset of monsoon.
N. What should be the optimum design to bring down costs?	**Annexure - 1**
O. Can an analysis of expenditures incurred thus far be undertaken to identify critical areas where costs can be reduced without compromising on efficiency of the system?	**Annexure -2**

P. If we want to ensure that there is no fresh contamination taking place as a consequence of our efforts then what are the action to be initiated? And parameters to be tracked?	1. Cleaning of the roofs before monsoon sets in. It should be done regularly, particularly the birds droppings. 2. Connecting pipes should not be broken. 3. The dug well should remain clean and tidy. 4. Parameters to be monitored: Electrical Conductivity (EC[1]), Most Probable Number (MPN[2]) once in a year during post-monsoon period.
Q. What action needs to be taken (for ensuring quality) prior to the effort?	1. The vendor must be trained on construction of pits etc. 2. The dug well must be cleaned, repaired, parapet must be repaired. 3. Community must sensitize for participation and maintenance.
R. How frequently subsequently the quality needs to be tracked?	1. Testing the Electrical Conductivity (EC), Most Probable Number (MPN) once in a year, during post-monsoon season from the open wells.

Community Participation and Stakeholders Engagement:

- Community should realize the need of recharge (Involve community starting from need assessment, ensure repeated meetings with community).
- Owner of dug well and owner of roofs agree to get involved and take responsibility.
- The owner of the roof agrees to clean before monsoon and take minor repair if needed.
- Community understands the need of maintenance of the recharge pit/ pipe and the dug well.
- Community agrees to pay for maintenance.
- The well owners (of all observation wells along with recharge well) within 150m for hard rock and 200m for soft rock area should agree to contribute for maintenance.
- Engagement with Gram Panchayat (GP)/Urban Local Bodies (ULB) is essential considering the resource envelop available with GP/ULB, which can be tapped for construction of recharge structure as well as maintenance needs.
- Local laboratory/technical institute to be linked with community for water quality testing (EC and MPN).

[1] An electrical conductivity (EC) or TDS meter is a quick method to estimate TDS. Water conducts electricity, but the dissolved minerals (ions) in water are what actually conduct the electricity.

[2] The most probable number (MPN) technique is a method for estimating the number of bacteria in a food or water sample. In this technique, replicate portions of the original sample are cultured to determine the presence or absence of microorganisms in each portion.

Annexure: 1

Runoff coefficient

Material	Run off coefficient
GI Sheet	0.9
Asbestos	0.8
Tiled	0.75
Concrete	0.7

Source: CGWB

Thickness of the filter material

Filter material sequence	Thickness of the material	Filter material	Grain size
1. At the top	0.4 m	Med to coarse sand	0.2 to 2.0 mm
2. Below the top layer	0.1 m	Charcoal	-
3. Below Charcoal	0.3 m	Gravel	10-30 mm
4. At the bottom	0.3 m	Pebble	60-100 mm
Total Thickness	**1.1 m**		

Roof area, Annual rainfall & size of pit matrix

Rainfall	Max Roof size (m2)	Size of the filter chamber (mXmXm)
400 mm	1,200	2mx2mx1.5m
600 mm	800	2mx2mx1.5m
800 mm	500	2mx2mx1.5m
1000 mm	475	3mX2mx 1.5m
1500 mm	325	3mx2mx1.5m
2000 mm	250	3mx2mx1.5m

Min size of roof 50 m^2

Roof area- rainfall size of pit relation

Annexure: 2

Cost of different components

Components	Maximum cost in respect of the total cost	Minimum cost in respect of the total cost	Average cost in respect of the total cost
Cost of cleaning, renovation, parapet & DW repair, wire mesh cover, hand pump fitting, weep hole etc.	69.9 %	20.0%	31.2%
Roof treatment and brick cordoning of roof	2.7 %	48.5%	15.9%
Fitting of pipes and fixtures	1.7 %	20.0%	7.5%
Pit digging and brickwork	9.3 %	23.1%	13.3%
Filter material, pit cover etc.	2.5 %	17.3%	5.6%
Miscellaneous	5.3 %	14.2%	9.2%

**All estimates are based on the recharge structures constructed by WaterAid India in Gulbarga, Raichur, Nuapada and Gaya districts, India.*

Where cost can be improved

1. No need to provide handpump in the recharge well
2. Look for possibilities to minimize the roof treatment. The intension is to get suitable roof to generate maximum runoff, not repairing of existing dilapidated roofs.
3. Unless necessary, recharge well may be kept open or cover with simple wire mesh to prevent leaves to fall.
4. Need to avoid too much dilapidated dug well. The repair/renovation/parapet repair should not exceed 35% of the total cost.

Maintenance cost and cost of recharge per unit volume based on total investment

Components	Maximum	Minimum	Average Cost
Total investment (INR)	1,73,360	93,499	1,07,438
Annual recharge (m^3/year)	319.71	124.2	161.8
Maintenance cost in INR (15 years life) @ 4%/year	1,04,016	56,099	64,463
Gross recharge in 15 years (m^3)	4,795.6	1,863.0	2,427.5
Cost of recharge per unit volume (INR/m^3)	57.84 (Koilipur, Gaya)	80.29 (Wadvatti, Raichur)	70.83

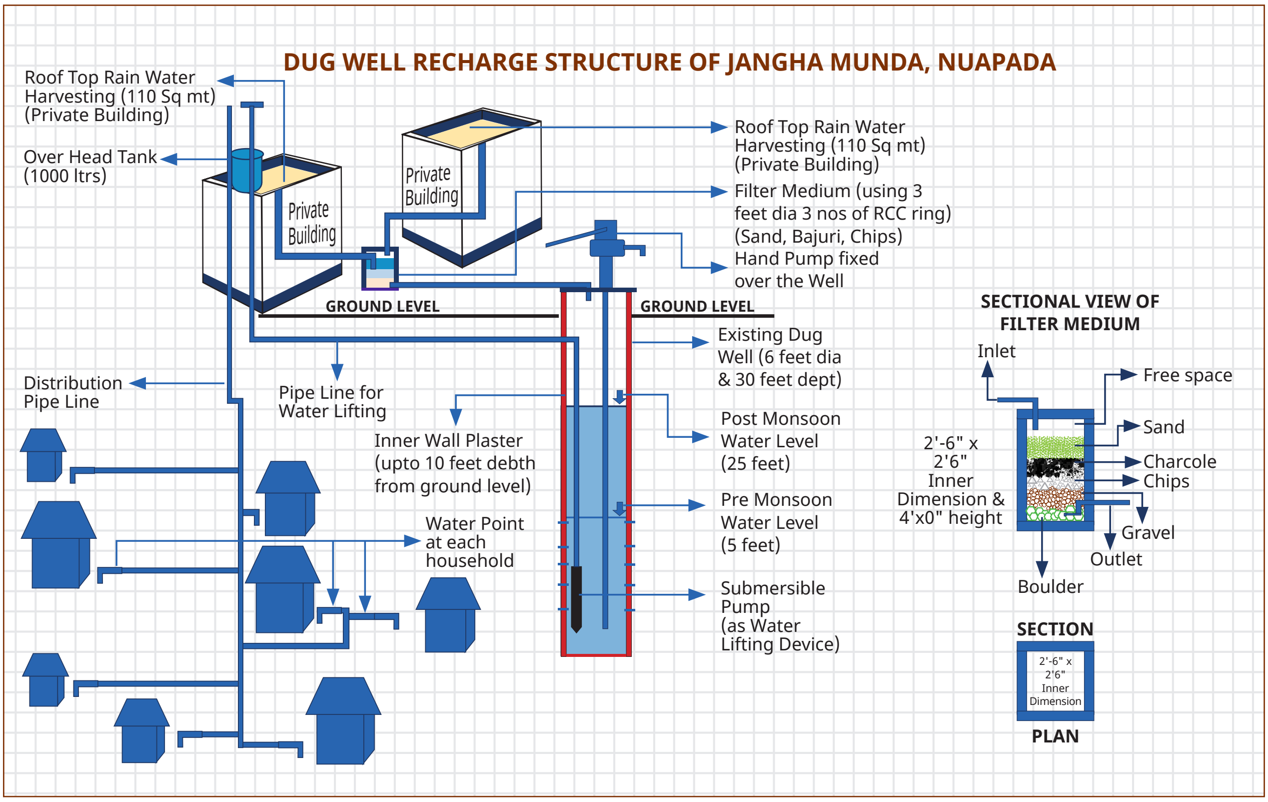
**All estimates are based on the recharge structures constructed by WaterAid India in Gulbarga, Raichur, Nuapada and Gaya districts, India.*

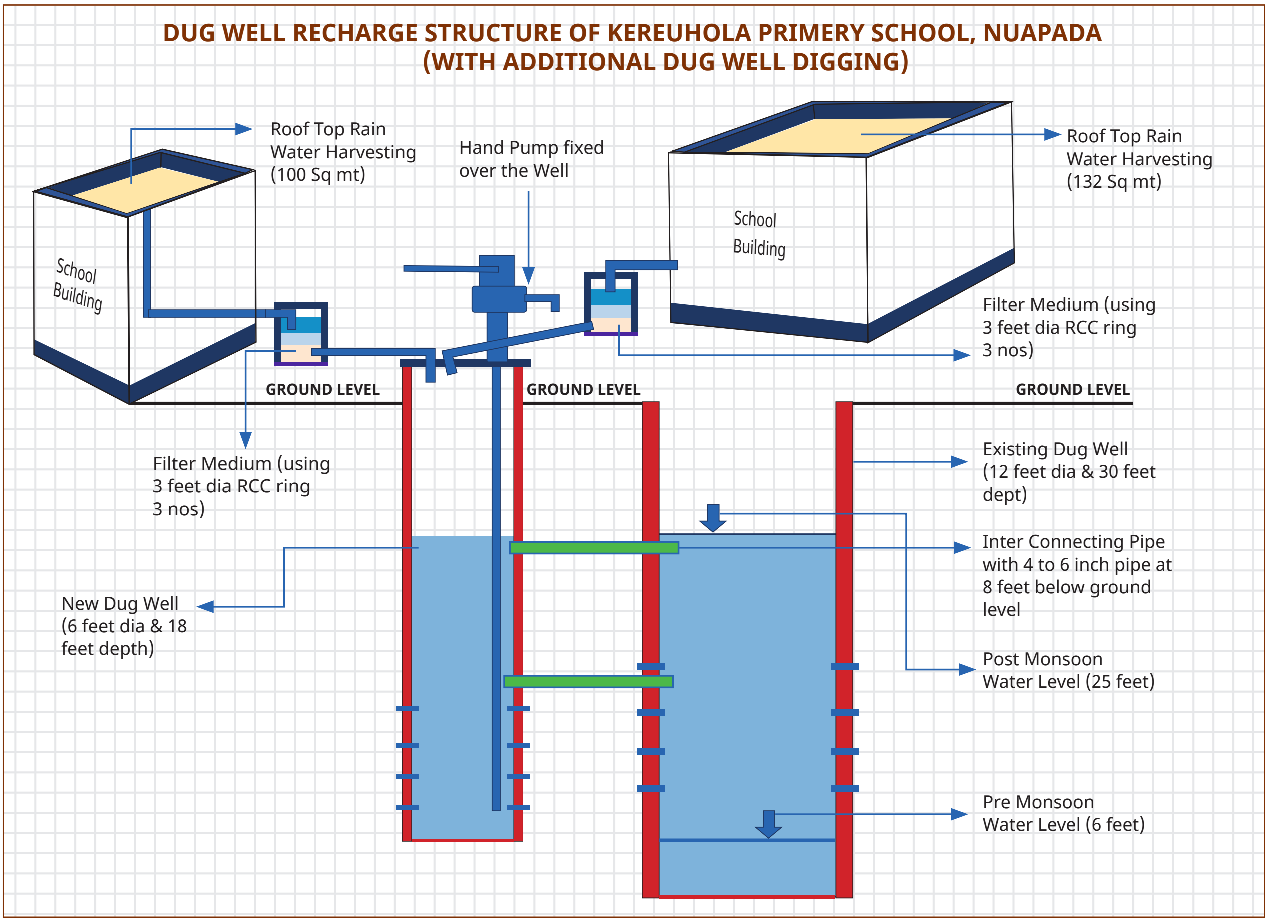
Total investment and maintenance cost as per the unit volume of recharge

Components	Maximum	Minimum
1. Cost of recharge per unit vol (INR/m^3)	255.33 (Rajapada, Odissa)	39.09 (Halsultanpur, Gulbrga)
2. Total Investment (INR)	1,05,945	99,974
3. Annual Recharge (m3/yr)	44.26	272.8

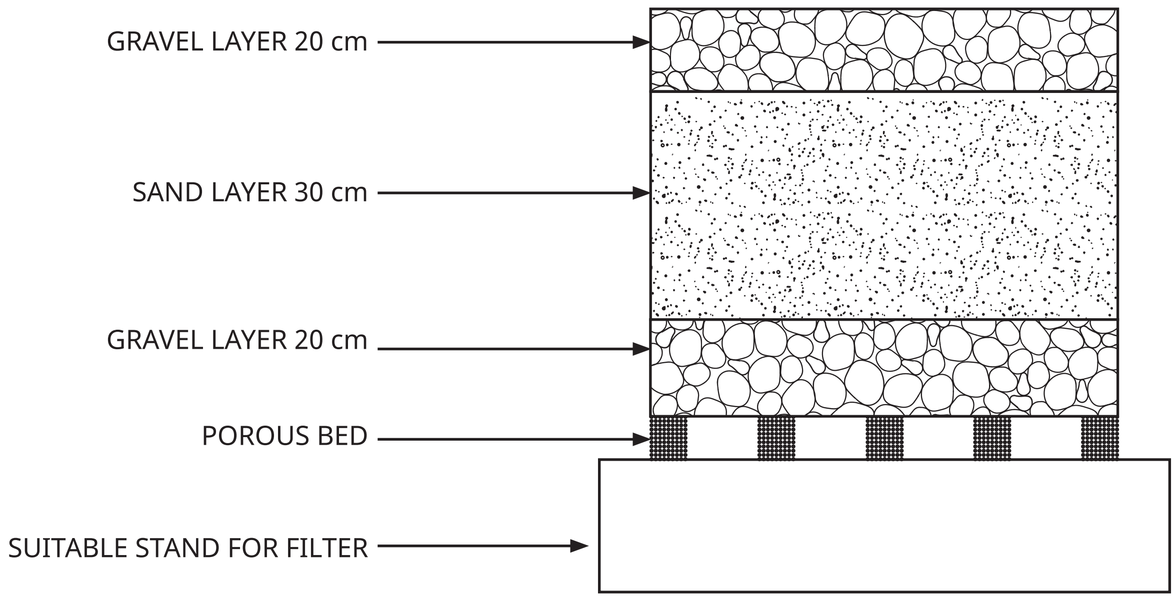
**All estimates are based on the recharge structures constructed by WaterAid India in Gulbarga, Raichur, Nuapada and Gaya districts, India.*

Designs

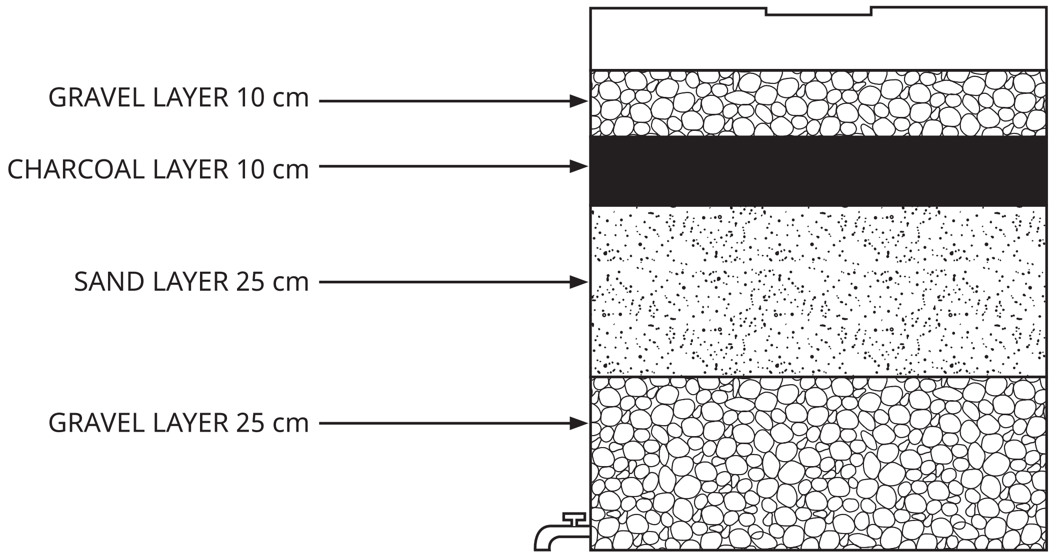

DUG WELL RECHARGE STRUCTURE OF JANGHA MUNDA, NUAPADA
Roof Top Rain Water Harvesting (110 Sq mt) (Private Building)
Over Head Tank (1000 ltrs)
Private Building
Private Building
Roof Top Rain Water Harvesting (110 Sq mt) (Private Building)
Filter Medium (using 3 feet dia 3 nos of RCC ring) (Sand, Bajuri, Chips)
Hand Pump fixed over the Well
GROUND LEVEL
GROUND LEVEL
Existing Dug Well (6 feet dia & 30 feet dept)
Distribution Pipe Line
Pipe Line for Water Lifting
Inner Wall Plaster (upto 10 feet debth from ground level)
Post Monsoon Water Level (25 feet)
Pre Monsoon Water Level (5 feet)
Water Point at each household
Submersible Pump (as Water Lifting Device)
SECTIONAL VIEW OF FILTER MEDIUM
Inlet
Free space
Sand
Charcole Chips
Gravel
Outlet
Boulder
2'-6" x 2'6" Inner Dimension & 4'x0" height
SECTION
2'-6" x 2'6" Inner Dimension
PLAN


DUG WELL RECHARGE STRUCTURE OF KEREUHOLA PRIMERY SCHOOL, NUAPADA
(WITH ADDITIONAL DUG WELL DIGGING)
Roof Top Rain Water Harvesting (100 Sq mt)
Hand Pump fixed over the Well
Roof Top Rain Water Harvesting (132 Sq mt)
School Building
School Building
Filter Medium (using 3 feet dia RCC ring 3 nos)
GROUND LEVEL
GROUND LEVEL
GROUND LEVEL
Filter Medium (using 3 feet dia RCC ring 3 nos)
Existing Dug Well (12 feet dia & 30 feet dept)
Inter Connecting Pipe with 4 to 6 inch pipe at 8 feet below ground level
New Dug Well (6 feet dia & 18 feet depth)
Post Monsoon Water Level (25 feet)
Pre Monsoon Water Level (6 feet)

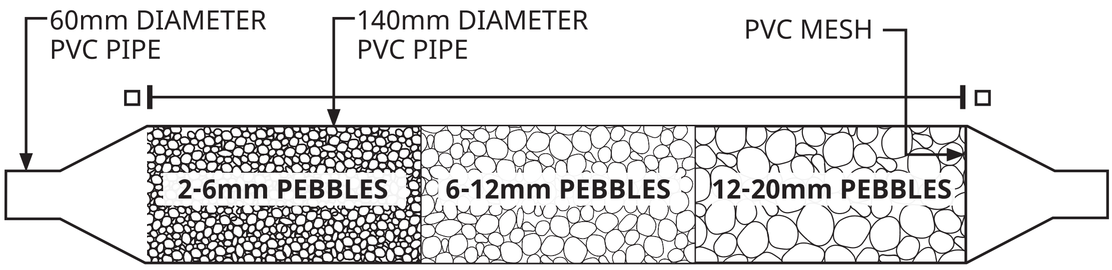
SAND FILTER



CHARCOAL WATER FILTER



DEWAS FILTER



Abbreviations

CGWB	Central Ground Water Board
M	Meter
BGL	Below Ground Level
MBGL	Meter Below Ground Level
M/Year	Meter per year
WL	Water Level
GSI	Geological Survey of India
SOI	Survey of India
GI	Galvanized Iron
Dia	Diameter
INR	Indian Rupee
Rs	Rupees
EC	Electrical Conductivity
OW	Open Well
M^3	Cubic Meter
M^2	Square Meter
Yrs	Years
CM	Centimetre
MPN	Most Probable Number