6.5
Water in the Community

6.5.3 Off-Campus Water Conservation Support

MRIIRS Weblink to SDG 6:

https://mriirs.edu.in/sdg06-clean-water-and-sanitation/

Off-Campus Water Conservation Support by MRIIRS:

MRIIRS with the funding of Department of Science and Technology, Government of India, has created rainwater recharge structure at **officer's colony, sector 15A Faridabad, Haryana, India** for water co-solving logging and groundwater depletion as a pilot project and with the hope to replicate it in entire city area.

As evidence in support to 6.5.3 **details of the project, photographs and video of constructed structure to solve the water logging problem is available. Feedback of local resident about the effectiveness of structure** is presented, All the data are available in public domain through, newspaper & web site of MRIIRS.

- ✓ **Video of Construction of Structures for Co-solving of Water Logging and Ground Water Depletion Issues in Sector 15A of Faridabad City of Haryana State of India:**

- ✓ **Video of interview of one of the residents of Sector 15A of Faridabad City of Haryana State of India:**

Co-solving of Water Logging and Ground Water Depletion Issues in Sector 15A of Faridabad City of Haryana State of India

Urban waterlogging and groundwater depletion are two diverse but major challenges of Indian cities under changing climatic conditions. The enhanced extreme events of rainfall in recent years along with rapidly altered hydrological conditions in urban environment pose conducive situation for urban water logging. On the other hand, intense and large withdrawal of groundwater, higher than the natural annual recharge has depleted the groundwater level severely in many Indian cities. A pilot project is executed in Faridabad Smart City of National Capital Region India, to combat water logging and to rejuvenate groundwater resource.

In the study all steps were undertaken meticulously, beginning from hydrogeological study, site selection, rainfall analysis, calculations of runoff generation, framing well design after identification of suitable recharge zones within depleted aquifer and determination of its intake capacity. It further elucidates estimation of suitable dimension of desilting chamber, fixing suitable dose of ferric chloride for coagulation and assessment of recharge volume. The constructed recharge system is tested whether it is working effectively as per the feedback obtained from independent sources. It has high scalability in similar hydrogeological situation in other parts of India.

Picture of Actual Waterlogging in the Officer's Colony Area of Sec-15A, Faridabad City of Haryana State of India

Details of Project:

The project of 36 months duration with 0.7012 crore budget, submitted with the title "**Co-solving water logging and groundwater depletion issues in parts of Faridabad Smart City using Underground Taming of Flood Water for Aquifer Storage and Recovery**" to the Department of Science and Technology, Government of India, got sanctioned to Manav Rachna CAWTM in May 2021.

- Under this investigation it was proposed to divert the urban flash flood creating water logging condition and is hampering day-to-day life during monsoon period to improve the groundwater condition within the depleted aquifer. This **aquifer storage and recovery project** of taming urban flood water is addressing two critical issues of urban hydrology to improve the sustainability.
  - ✓ Developing solutions to the street water logging and groundwater depletion through Underground Taming of Flood water (UTF) for Aquifer Storage Recovery (ASR) in Faridabad Smart City.
  - ✓ Identification of suitable aquifer zones for recharge in the Faridabad Smart City

- **Impact Assessment**: Under this sponsored project, MRIIRS with the funding of Department of Science and Technology, Government of India, has created rainwater recharge structure at officer's colony, sector 15A Faridabad, Haryana, India for water co-solving logging and groundwater depletion as a pilot project and with the hope to replicate it in entire city area.
  - ✓ Real time monitoring of groundwater level, temperature, and electrical conductivity for impact assessment on the ground water system.
  - ✓ Periodic monitoring of groundwater quality to assess the impact of Aquifer Storage and Recovery through comparison of the source water and product water.
  - ✓ To study the reduction in energy consumption for groundwater pumping due to UTF & ASR

SDG 6- CLEAN WATER AND SANITATION

- Project Investigators: Dr. Arunangshu Mukherjee (Principal Investigator- PI)
  Dr. Nidhi Didwania (Co- PI)
  Ms. Alifia Ibkar, Research Assistant

- **Capacity Building for Replication:** Capacity building of Urban Local Body (ULB) officials such as Municipal Corporation Faridabad (MCF), Haryana Shehri Vikas Pradhikaran (HUDA) & Faridabad Smart City Limited (FSCL) etc related to Underground Taming of Flood water (UTF) for Aquifer Storage Recovery (ASR).

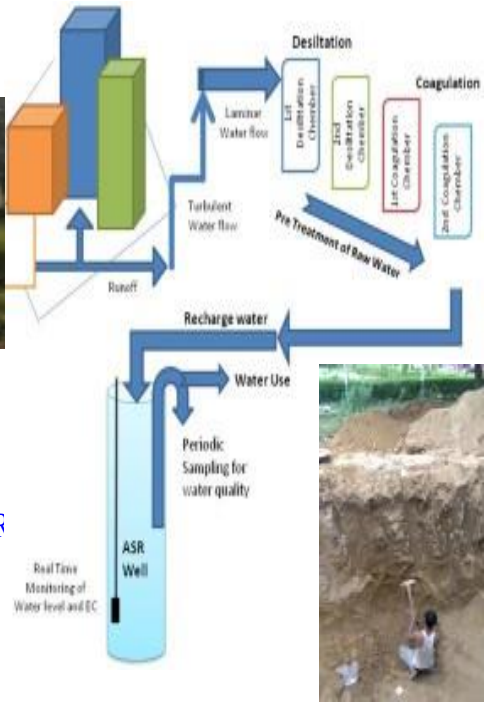
DEPARTMENT OF SCIENCE & TECHNOLOGY
Ministry of Science & Technology
Government of India

Department of Science and Technology
Technology Missions Division,
Water Technology Initiative Programme
WTI - (Action Research)

MANAV RACHNA
vidyanatariksha

Co-solving Water logging and Groundwater depletion issue in parts of Faridabad S using Underground Taming of Flood water for Aquifer Storage and Recover

- Topographic survey and DGPS elevation mapping of the area of interest
- Micro level hydrological and hydrogeological study for designing for UTFW during pre monsoon and monsoon period
- Surface geophysical Investigations VES & Profiling
- Study for construction of connecting drain, desiltation chambers, coagulation chamber
- Experiments for selection of suitable Iron based coagulant
- Study for Optimization of flow rate and dosing of coagulan
- Auger hole drilling and slug testing– Vadose zone study
- Drilling of bore hole andlitho sampling
- Subsurface geophysical logging
- Well completion and development
- Pumping test for aquifer characterization and well efficiency test
- Collection and analysis of groundwater samples for base level data acquisition
- DWLR with EC and Temp sensor and installation
- Installation of UTFW system by connection civil construction and drilled well for ASF
- Installation of energy meter and pump
- Water sampling for analysis of regular and emerging pollutants /contaminants
- Impact assessment of UTFW



SDG 6- CLEAN WATER AND SANITATION

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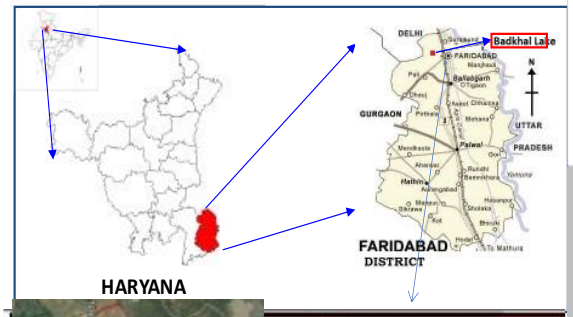
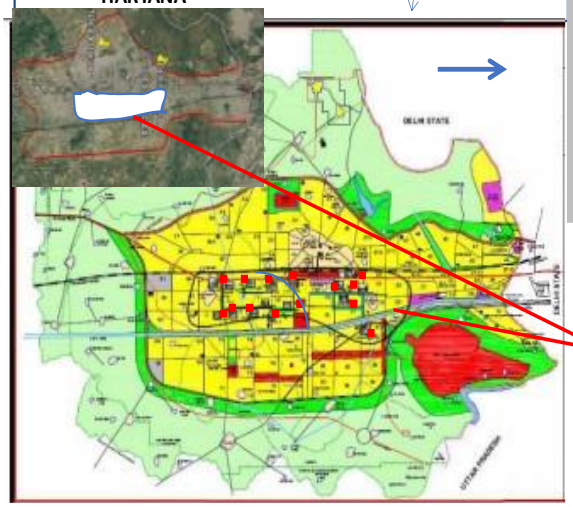
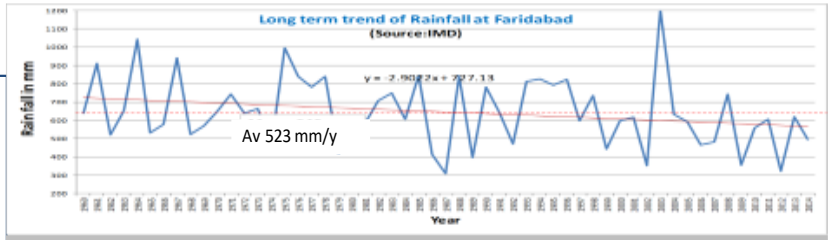
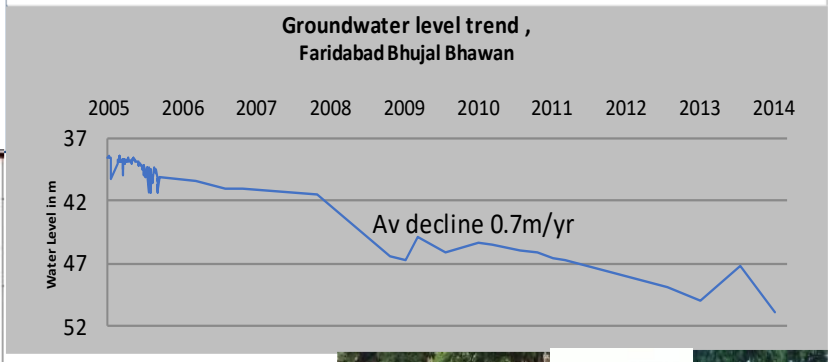
Faridabad Smart City









Faridabad Area-187Km^2
Population- 16 lakh
Water logging area-17Km^2
Effected population-~3lakh
Present av DTW-40mbgl

Water logging during rain

Construction of Structures for Co-solving of Water Logging and Ground Water Depletion Issues in Officer's Colony, Sector 15A of Faridabad City of Haryana State of India

MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEACH AND STUDIES, FARIDABAD

SDG 6- CLEAN WATER AND SANITATION

Inspection of site - Officer's Colony, Sector 15A of Faridabad City of Haryana State of India

SDG 6- CLEAN WATER AND SANITATION

Constructed Structure at Officer's Colony, Sector 15A of Faridabad City of Haryana State of India

Media Coverage:

27th Sept 2022, Jagran

एक्यूफर स्टोरेज एवं रिकवरी सिस्टम से होगा भूजल संरक्षण

जागरण संवाददाता, फरीदाबाद: शहर में जलभराव बहुत बड़ी समस्या है। काफी जगह ऐसी हैं, जहां वर्षा के कई दिन बाद भी जलभराव रहता है। नगर निगम के तमाम प्रयास के बावजूद समाधान नहीं हो सका है।

जल संरक्षण

अब केंद्र सरकार की जल प्रौद्योगिकी पहल के तहत विज्ञान और प्रौद्योगिकी विभाग जलभराव से मुक्ति को लेकर आगे आया है। विभाग से जारी किए गए बजट की मदद से सेक्टर-15ए आफिसर्स कालोनी में एक्यूफर स्टोरेज एवं रिकवरी सिस्टम (जलभृत भंडारण और पुनर्प्राप्ति प्रणाली) तैयार किया है।

दूसरा सिस्टम सेक्टर-16ए स्थित बीएंडआर कालोनी के अंदर निर्माण

जलभराव से छुटकारे और भूजल स्तर बढ़ाने के लिए सेक्टर-15ए स्थित आफिसर्स कालोनी में बनाया गया एक्यूफर स्टोरेज एंड रिकवरी सिस्टम ● जागरण

● केंद्र सरकार के बजट से मानव रचना जल प्रौद्योगिकी केंद्र के निदेशक की देखरेख में बनाया गया सिस्टम

● सेक्टर-15ए में आफिसर्स कालोनी के अंदर स्थापित किया है सिस्टम, रोज 20 लाख लीटर पानी जा सकेगा भूजल में

जलभराव से छुटकारे को लेकर शोध करने की जिम्मेदारी मिली थी। ट्रायल के रूप में दो जगह को चुना है। एक जगह सिस्टम बन गया है दूसरी जगह बनने वाला है। जल्द दो जगह और सिस्टम तैयार कराया जाएगा। तीन साल तक देखरेख करेंगे। उसके बाद लोक निर्माण विभाग को सिस्टम हैंडओवर कर दिए जाएंगे।

- प्रोफेसर डा. अरुणांगशु मुखर्जी, निदेशक, मानव रचना जल प्रौद्योगिकी केंद्र

किया जा रहा है। यह सिस्टम मानव रचना यूनिवर्सिटी के जल प्रौद्योगिकी केंद्र के निदेशक डा. अरुणांगशु मुखर्जी की निगरानी में तैयार किया गया है। मानव रचना के इस विभाग को ही केंद्र द्वारा बजट जारी किया गया था।

टीम ने किया था निरीक्षण: डा. अरुणांगशु मुखर्जी व उनकी टीम ने शहर के कुछ ऐसे स्थानों का निरीक्षण किया, जहां काफी जलभराव होता है। इन सभी जगह सिस्टम लगाने की तैयारी शुरू की गई है। इस योजना से न केवल जलभराव से छुटकारा मिलेगा, बल्कि यह पानी जमीन के नीचे भी जा सकेगा।

20 लाख लीटर पानी रोज जाएगा जमीन के नीचे: आफिसर्स कालोनी में तैयार हुए सिस्टम के माध्यम से रोज 20 लाख लीटर पानी जमीन के नीचे पहुंचाया जा सकेगा। जहां सिस्टम बना है, वह आसपास के क्षेत्र का सबसे निचला हिस्सा है। इसलिए यहां अधिक जलभराव होता है। नीचे तीन चैंबर बनाए गए हैं। पानी एक से दूसरे और फिर तीसरे चैंबर में जाएगा। इससे पानी के अंदर जो कचरा होगा, वह पहले चैंबर में ही रुक जाएगा। बचा-खुचा दूसरे में ठहर जाएगा। तीसरे चैंबर तक पानी बिना कचरे के जाएगा। इसके बाद चौथे चैंबर में पानी फिल्टर होकर जमीन के नीचे चला जाएगा।

खिसक रहा है भूजल: हर साल वर्षा का पानी व्यर्थ बह जाता है। जलभराव से न केवल लोगों को परेशानी होती है बल्कि भूजल स्तर पर भी इसका असर पड़ रहा है। वैसे भी भूजल के मामले में अपना जिला डार्क जोन में है। सेक्टरों व कालोनियों में नगर निगम के ट्यूबवेल के बोर के नीचे पानी नहीं बचा है।

इसलिए लगाने के सालभर बाद ही ठप हो रहे हैं। अरावली तलहटी में बसे गांव में भूजल स्तर 500 से 700 फुट पर पहुंच गया है। पूरा शहर यमुना नदी किनारे बसे हुए रेनीवेल पर निर्भर है। यदि जलभराव वाली जगह रेनवाटर हार्वेस्टिंग सिस्टम लगा दिए जाएं तो इससे बूंद-बूंद पानी को जमीन के नीचे पहुंचाया जा सकता है।

- ✓ The Project sanction order by Department of Science and Technology is appended.
- ✓ NoC by Faridabad Smart City Limited for Construction of Structures.
- ✓ The book chapter published related to this DST sponsored work titled '**Combating urban waterlogging with support from underlaying over exploited aquifer: A case study from India**' is also appended.

DST/TMD/EWO/WTI/2K19/EWFH/2019/237(G)
Government of India
Ministry of Science & Technology
Department of Science & Technology (Technology Mission Division)

Technology Bhavan, New Delhi
Dated: 21/05/2021

Sanction Order

Subject: Financial support for project entitled **"Co-solving water logging and groundwater depletion issue in parts of Faridabad Smart City using Underground Taming of Flood water for Aquifer Storage and Recovery"** submitted by **Dr. Arunangshu Mukherjee** from **Manav Rachna International University- Faridabad.**

Sanction of the President is hereby accorded to the approval of the above-mentioned project at a total cost of **₹ 70,12,720/- (*Rupees Seventy Lakhs, Twelve Thousands and Seven Hundred Twenty Only)***, for a duration of **3 years**. The detailed breakup of the grant for Capital and General Components are given below:

Capital Component: ₹ 8,62,000/-
General Component: ₹ 61,50,720/-

S.No.	Item head	1st Year	2nd Year	3rd Year	Total
A.	**Capital-Non Recurring Cost**				
	Photo meter with accessories (1 No.)	5,07,000	0	0	5,07,000
	DWLR with T &EC sensor and telemetry and real time data display unit (1 No.)	3,05,000	0	0	3,05,000
	Lap top/ Desk Top (1 No.)	50,000	0	0	50,000
	Sub Total (Capital Cost)	**8,62,000**	0	0	**8,62,000**
B	**General-Recurring Cost**				
	Manpower "Project Assistant" (01) 20000+ 16% HRA per month	2,78,400	2,78,400	2,78,400	8,35,200
	Other cost	9,00,000	33,28,000	0	42,28,000
	Consumables	50,000	50,000	50,000	1,50,000
	Travel	50,000	50,000	50,000	1,50,000
	Contingencies	50,000	50,000	50,000	1,50,000
	Sub-Total (B)	**13,28,400**	**37,56,400**	**4,28,400**	**55,13,200**
C	**Total Cost (A + B)**	**21,90,400**	**37,56,400**	**4,28,400**	**63,75,200**
D	Overhead	2,19,040	3,75,640	42,840	6,37,520
	Sub Total (General Cost)	**15,47,440**	**41,32,040**	**4,71,240**	**61,50,720**
E	**G. Total Cost (C + D)**	**24,09,440**	**41,32,040**	**4,71,240**	**70,12,720**

2. The sanction of the President is also accorded to the release of **₹ 15,47,440/- (Rupee Fifteen Lakh, Forty Seven Thousand, and Four Hundred Forty Only)** to **Manav Rachna International University-Faridabad** being the first installment of grant under "**General Component**" for implementation of the above mentioned project.

3. This sanction is subject to the condition that the grantee organisation will furnish to the Department of Science & Technology, financial year wise Utilization Certificate (UC) in the proforma prescribed as per GFR 2017 and audited statement of expenditure (SE) along with up to date progress report at the end of each financial year duly reflecting the interest earned / accrued on the grants received under the project. This is also subject to the condition of submission of the final statement of expenditure, utilization certificate and project completion report within one year from the scheduled date of completion of the project.

4. The grantee organisation will have to enter & upload the Utilization Certificate in the PFMS portal besides sending it in physical form to this Division. The subsequent/final instalment will be released only after confirmation of the acceptance of the UC by the Division and entry of previous Utilization Certificate in the PFMS.

5. If the grant has been released under capital head through separate sanction order under the same project for purchase of equipment(s), separate SE/UC has to be furnished for the released Capital head grant.

6. The grant-in-aid being released is subject to the condition that

   a. A transparent procurement procedure in line with the Provisions of General Financial Rules 2017 will be followed by the Institute/Organisation under the appropriate rules of the grantee organisation while procuring capital assets sanctioned for the abovementioned project and a certificate to this effect will be submitted by the Grantee organisation immediately on receipt of the grant:
   b. While submitting Utilization Certificate/Statement of Expenditure, the organisation has to ensure submission of supporting documentary evidences with regard to purchase of equipment/capital assets as per the provisions of GFR 2017. Subsequent release of grants under the project shall be considered only on receipt of the said documents.

7. The grantee organization will maintain separate audited account for the project and the entire amount of grant will be kept in an interest bearing bank account. For Grants released during F.Y. 2017-18 and onwards, all interests and other earnings, against released Grant shall be remitted to Consolidated Fund of India (through Non-Tax Receipt Portal (NTRP), i.e., www.Bharatkosh.gov.in),immediately after finalization of accounts, as it shall not be adjusted towards future release of grant. A certificate to this effect shall have to be submitted along with Statement of Expenditure/Utilization Certificate for considering subsequent release of grant/closure of project accounts. DST reserves solerights on the assets created out of grants. Assets acquired wholly or substantially out of government grants (except those declared as obsolete and unserviceable or condemned in accordance with the procedure laid down in GFR 2017), shall not be disposed of without obtaining the prior approval of DST.

8. DST reserves sole rights on the assets created out of grants. Assets acquired wholly or substantially out of government grants (except those declared as obsolete and unserviceable or condemned in accordance with the procedure laid down in GFR 2017), shall not be disposed of without obtaining the prior approval of DST.

9. In case the scheme provides for payment of honorarium / remuneration / fellowship / scholarship to the PI, a para may suitably be incorporated in the DSO to the effect that "PI is not drawing any emoluments/ salary/fellowship from any other project either supported by DST or by any other funding agency.

The account of the grantee organisation shall be open to inspection by the sanctioning authority and audit (both by C&AG of India and Internal Audit by the Principal Accounts Office of the DST), whenever the organisation is called upon to do so, as laid down under Rule 236(1) of General Financial Rules2017.

11. Due acknowledgement of technical support / financial assistance resulting from this project grant should mandatorily be highlighted by the grantee organisation in bold letters in all publications / media releases as well as in the opening paragraphs of their Annual Reports during and after the completion of the project.

12. Failure to comply with the terms and conditions of the Bond will entail full refund with interest in terms of Rule 231 (2) of GFR2017.

13. The expenditure involved is debitable to-

Demand No.88	Department of Science and Technology for the year 2021-22
3425	Other Scientific Research (Major Head)
60	Others
60.200	Assistance to Other Scientific Bodies (Minor head)
70	Innovation, Technology Development and Deployment
70.00.31	**Grant-in-aid General for the year 2021-2022**
	(Previous: TDP-3425.60.200.26.01.31-(SERI/WTI)

14. The amount of **₹ 15,47,440/- (Rupee Fifteen Lakh, Forty Seven Thousand, and Four Hundred Forty Only)** will be drawn by the Drawing and Disbursing Officer, DST and will be disbursed to **Manav Rachna International University- Faridabad.** The bank details for electronic transfer of funds through RTGS are given below: -

Name of the Account Holder	MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH AND STUDIES
Name of the bank	Indusind Bank
Branch Address	Indusind Bank, NIT Faridabad Branch, GF,1-A/268 NIT, New Town, Neelam –Bata Road, Faridabad 121001
Agency Code (PFMS)	MRIU
IFSC code	INDB0000702
Account Number	201003388847
MICR No.	110234066

15. No release of funds will be allowed beyond the 1st quarter of FY 2021-22 in case the Umbrella Scheme under which the Project is funded, is not appraised and approved by then.

16. It is mandatory to use EAT module in PFMS, failing which no further funds shall be released.

17. As per Rule 234 of GFR 2017, this sanction has been entered at S. No.**38** (TMD,WE) in the register of grants maintained in the Division for the scheme(ITDD).

18. As per Rule 237 of GFR 2017, Time Schedule for submission of annual accounts - The dates prescribed for submission of the annual accounts for Audit leading to the issue of Audit Certificate by the Comptroller and Auditor General of India and for submission of annual report and audited accounts to the nodal Ministry for timely submission to the Parliament are listed below:-

(i) Approved and authenticated annual accounts to be made available by the Autonomous Body to the concerned Audit Office and commencement of audit of annual accounts-30thJune

(ii) Issue of the final SAR in English version with audit certificate to Autonomous Body/Government concerned -31stOctober

(iii) Submission of the Annual Report and Audited Accounts to the Nodal for it to be laid on the Table of the Parliament -31stDecember.

19. The organization/Institute/University should ensure that the technical support/financial assistance provided to them by the Department of Science and Technology should invariably be Highlighted / acknowledged in their media releases as well as in bold letters in the opening paragraph of their Annual Report.

20. It is important that the information and knowledge generated through the use of these funds are made publicly available as soon as possible. In order to achieve the aforementioned objectives, each institution is encouraged to set up its own inter-operable institutional open access repository ("IR") for its research papers and review articles published in peer reviewed journals. The Ministry of Science and Technology has set up a central harvester (www.sciencecentral.in) that will harvest the full text and metadata of these publications. Kindly update the findings accordingly.

21. The organization named **Manav Rachna International University-Faridabad** and partnering institutes agrees to make reservations for Scheduled Castes and Scheduled Tribes or OBC in the posts or services under its control on the lines indicated by the Government of India.

22. The goods (consumables/equipment) available in GeM portal are to be procured mandatorily online through GeM only.

23. The Organization/Institute/University should ensure that DoE Guidelines followed for International Travel.

24. This issues with the concurrence of IFD Vide their Concurrence Dy. No.**277** dated **21/05/2021.**

(Dr. Sanjai Kumar)
Scientist-D
Email: Sanjai.k@gov.in

1. Cash Section (3 copies) for preparing the bill and remitting the amount to the above grantee.
2. Accounts Section, DST, New Delhi.
3. IFD, Department of Science & Technology, New Delhi.
4. Director of Audit (CW & M-II), AGCR Building, IP Estate, New Delhi.
5. **Principal Investigator (PI)**
   Name: Dr Arunangshu Mukherjee
   Designation: Professor
   Department: Department of Civil Engineering amp CA Water TampM , FET
   Institute/University: MANAV RACHNA INTERNATIONAL UNIVERSITY- Faridabad
   Address: AT25,CAWTM, Manav Rachna International University, Sector,43, Delhi–Surajkund Road, Faridabad – 121004.
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6. Sanction folder
7. Office Copy
8. Head- TMD(EWO)

(Dr. Sanjai Kumar)
Scientist-D

DST/TMD/EWO/WTI/2K19/EWFH/2019/237 (C)
Government of India Ministry of Science & Technology
Department of Science & Technology (Technology Mission Division)

Technology Bhavan, New Delhi
Dated: 21/05/2021

Sanction Order

Subject: Financial support for project entitled **"Co-solving water logging and groundwater depletion issue in parts of Faridabad Smart City using Underground Taming of Flood water for Aquifer Storage and Recovery"** submitted by **Dr. Arunangshu Mukherjee** from **Manav Rachna International University- Faridabad**

Sanction of the President is hereby accorded to the approval of the above-mentioned project at a total cost of **₹ 70,12,720/- (*Rupees Seventy Lakhs, Twelve Thousands and Seven Hundred Twenty Only*** for a duration of **3 years**. The detailed breakup of the grant for Capital and General Components are given below:

Capital Component: ₹ 8,62,000/-
General Component: ₹ 61,50,720/-

S.No.	Item head	1st Year	2nd Year	3rd Year	Total
A.	**Capital-Non Recurring Cost**				
	Photo meter with accessories (1 No.)	5,07,000	0	0	5,07,000
	DWLR with T &EC sensor and telemetry and real time data display unit (1 No.)	3,05,000	0	0	3,05,000
	Lap top/ Desk Top (1 No.)	50,000	0	0	50,000
	Sub Total (Capital Cost)	**8,62,000**	0	0	**8,62,000**
B	**General-Recurring Cost**				
	Manpower "Project Assistant" (01) 20000+ 16% HRA per month	2,78,400	2,78,400	2,78,400	8,35,200
	Other cost	9,00,000	33,28,000	0	42,28,000
	Consumables	50,000	50,000	50,000	1,50,000
	Travel	50,000	50,000	50,000	1,50,000
	Contingencies	50,000	50,000	50,000	1,50,000
	Sub-Total (B)	**13,28,400**	**37,56,400**	**4,28,400**	**55,13,200**
C	**Total Cost (A + B)**	**21,90,400**	**37,56,400**	**4,28,400**	**63,75,200**
D	Overhead	2,19,040	3,75,640	42,840	6,37,520
	Sub Total (General Cost)	**15,47,440**	**41,32,040**	**4,71,240**	**61,50,720**
E	**G. Total Cost (C + D)**	**24,09,440**	**41,32,040**	**4,71,240**	**70,12,720**

2. The sanction of the President is also accorded to the release of **₹ 8,62,000/- (Rupee Eight Lakhs Sixty Two Thousand, Only)** to **Manav Rachna International University- Faridabad** being the first installment of grant under "**Capital Component**" for implementation of the above mentioned project.

3. This sanction is subject to the condition that the grantee organisation will furnish to the Department of Science & Technology, financial year wise Utilization Certificate (UC) in the proforma prescribed as per GFR 2017 and audited statement of expenditure (SE) along with uptodateprogressreportattheendofeachfinancialyeardulyreflectingtheinterestearned/ accrued on the grants received under the project. This is also subject to the condition of submission of the final statement of expenditure, utilization certificate and project completion report within one year from the scheduled date of completion of the project.

4. The grantee organisation will have to enter & upload the Utilization Certificate in the PFMS portal besides sending it in physical form to this Division. The subsequent/final instalment will be released only after confirmation of the acceptance of the UC by the Division and entry of previous Utilization Certificate in the PFMS.

5. If the grant has been released under capital head through separate sanction order under the same project for purchase of equipment(s), separate SE/UC has to be furnished for the released Capital head grant.

6. The grant-in-aid being released is subject to the condition that

   a. A transparent procurement procedure in line with the Provisions of General Financial Rules 2017 will be followed by the Institute/Organisation under the appropriate rules of the grantee organisation while procuring capital assets sanctioned for the above mentioned project and a certificate to this effect will be submitted by the Grantee organisation immediately on receipt of the grant.

   b. While submitting Utilization Certificate/Statement of Expenditure, the organisationhas to ensure submission of supporting documentary evidences with regard to purchase of equipment/capital assets as per the provisionsof GFR 2017. Subsequent release of grants under the project shall be considered only on receipt of the said documents.

7. The grantee organization will maintain separate audited account for the project and the entire amount of grant will be kept in an interest bearing bank account. For Grants released during F.Y. 2017-18 and onwards,all interests and other earnings, against released Grant shall be remitted to Consolidated Fund of India (through Non-Tax Receipt Portal (NTRP), i.e., www.Bharatkosh.gov.in), immediately after finalization of accounts, as it shall not be adjusted towards future release of grant. A certificate to this effect shall have to be submitted along with Statement of Expenditure/Utilization Certificate for considering subsequent release of grant/closure of project accounts. DST reserves sole rights on the assets created out of grants. Assets acquired wholly or substantially out of government grants (except those declared as obsolete and unserviceable or condemned in accordance with the procedure laid down in GFR 2017), shall not be disposed of without obtaining the prior approval of DST.

8. DST reserves sole rights on the assets created out of grants. Assets acquired wholly or substantially out of government grants (except those declared as obsolete and unserviceable or condemned in accordance with the procedure laid down in GFR 2017), shall not be disposed of without obtaining the prior approval of DST.

9. In case the scheme provides for payment of honorarium / remuneration / fellowship / scholarship to the PI, a para may suitably be incorporated in the DSO to the effect that "PI is not drawing any emoluments/ salary/fellowship from any other project either supported by DST or by any other funding agency.

10. The account of the grantee Organisation shall be open to inspection by the sanctioning authority and audit (both by C&AG of India and Internal Audit by the Principal Accounts Office of the DST), whenever the Organisation is called upon to do so, as laid down under Rule 236(1) of General Financial Rules2017.

11. Due acknowledgement of technical support / financial assistance resulting from this project grant should mandatorily be highlighted by the grantee organisation in bold letters in all publications / media releases as well as in the opening paragraphs of their Annual Reports during and after the completion of the project.

12. Failure to comply with the terms and conditions of the Bond will entail full refund with interest in terms of Rule 231 (2) of GFR2017.

13. The expenditure involved is debitable to-

Demand No. 88	Department of Science and Technology for the year 2021-22
3425	Other Scientific Research (Major Head)
60	Others
60.200	Assistance to Other Scientific Bodies (Minor head)
70	Innovation, Technology Development and Deployment
70.00.35	**Grant for creation of capital assets for the year2021-2022**
	(Previous: TDP-3425.60.200.26.01.35- (SERI/WTI)

14. The amount of **₹ 8,62,000/- (Rupee Eight Lakhs Sixty Two Thousand, Only)** to will be drawn by the Drawing and Disbursing Officer, DST and will be disbursed **Manav Rachna International University- Faridabad.** The bank details for electronic transfer of funds through RTGS are given below:-

15.15.

Name of the Account Holder	MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH AND STUDIES
Name of the bank	Indusind Bank
Branch Address	Indusind Bank, NIT Faridabad Branch, GF,1-A/268 NIT, New Town, Neelam –Bata Road, Faridabad 121001
Agency Code (PFMS)	MRIU
IFSC code	INDB0000702
Account Number	201003388847
MICR No.	110234066

16. No release of funds will be allowed beyond the 1st quarter of FY 2021-22 in case the Umbrella Scheme under which the Project is funded, is not appraised and approved by then.

17. It is mandatory to use EAT module in PFMS, failing which no further funds shall be released.

18. As per Rule 234 of GFR 2017, this sanction has been entered at S. No. **39** (TMD, WE) in the register of grants maintained in the Division for the scheme(ITDD).

19. As per Rule 237 of GFR 2017, Time Schedule for submission of annual accounts - The dates prescribed for submission of the annual accounts for Audit leading to the issue of Audit Certificate by the Comptroller and Auditor General of India and for submission of annual report and audited accounts to the nodal Ministry for timely submission to the Parliament are listed below:-

(i) Approved and authenticated annual accounts to be made available by the Autonomous Body to the concerned Audit Office and commencement of audit of annual accounts-30th June.

(ii) Issue of the final SAR in English version with audit certificate to Autonomous Body/ Government concerned -31st October.

(iii) Submission of the Annual Report and Audited Accounts to the Nodal for it to be laid on the Table of the Parliament -31stDecember.

20. The organization/Institute/University should ensure that the technical support/financial assistance provided to them by the Department of Science and Technology should invariably be highlighted/acknowledged in their media releases as well as in bold letters in the opening paragraph of their Annual Report.

21. It is important that the information and knowledge generated through the use of these funds are made publicly available as soon as possible. In order to achieve the aforementioned objectives, each institution is encouraged to set up its own inter-operable institutional open access repository ("IR") for its research papers and review articles published in peer reviewed journals. The Ministry of Science and Technology has set up a central harvester (www.sciencecentral.in) that will harvest the full text and metadata of these publications. Kindly update the findings accordingly.

22. The organization named **Manav Rachna International University-Faridabad** and partnering institutesagrees to make reservations for Scheduled Castes and Scheduled Tribes or OBC in the posts or services under its control on the lines indicated by the Government of India.

23. The goods (consumables/equipment) available in GeM portal are to be procured mandatorily online through GeM only.

24. The Organization/Institute/University should ensure that DoE Guidelines followed for International Travel.

25. This issues with the concurrence of IFD Vide their Concurrence Dy. No. **278** dated **21/05/2021.**

(Dr. Sanjai Kumar)
Scientist-D
Email: Sanjai.k@gov.in

1. Cash Section (3 copies) for preparing the bill and remitting the amount to the above grantee.
2. Accounts Section, DST, New Delhi.
3. IFD, Department of Science & Technology, New Delhi.
4. Director of Audit (CW & M-II), AGCR Building, IP Estate, New Delhi.
5. **Principal Investigator (PI)**
   Name: Dr Arunangshu Mukherjee
   Designation: Professor
   Department: Department of Civil Engineering amp CA Water TampM , FET
   Institute/University: MANAV RACHNA INTERNATIONAL UNIVERSITY- Faridabad
   Address: AT25,CAWTM, Manav Rachna International University, Sector,43, Delhi –Surajkund Road, Faridabad – 121004.
   Email: arunangshu.fet@mriu.edu.in, arunmuk102@gmail.com
   Mobile: 9968805450

   Co-Principal Investigator (Co-PI)
   Name: Dr. Nidhi Didwania
   Designation: Associate Professor,
   Department: Department of Biotechnology
   Institute/University: Manav Rachna International University- Faridabad
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Co-Principal Investigator (Co-PI)

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(Dr. Sanjai Kumar)
Scientist-D

FARIDABAD SMART CITY LIMITED

Regd. Office.: Municipal Corporation Faridabad B.K Chowk N.I.T. Faridabad Haryana 121001
Corp. Office.: Plot No. 35, Nain Sadan, 3rd floor, Sector-20A, Faridabad
Email: faridabadsmartcitylimited@gmail.com | Website: -www.smartcityfaridabad.co.in
Tel: 9599780918 **GSTIN**-06AACCF9193L1Z4

To

Superintending Engineer
B&R Division, Faridabad.

Memo No. FSCL/ENGG/2021/833 Date: 18.08.2021

Subject: NOC for construction of recharge structure and transfer of rights regarding

Manav Rachna International Institute of Research and Studies in association with Faridabad Smart City Limited is planning to construct recharge structure in following listed locations for co-solving the water logging and groundwater depletion issue in parts of Faridabad Smart City area.

- Circuit house road, Sector 16A

This project is funded by Department of Science and Technology (DST), Government of India. The proposed structures are to be built in government land and after construction will be handed over to concerned department for further monitoring and maintenance after the project period of 36 months.

Faridabad Smart City Limited is associated in hand holding of Manav Rachna International Institute of Research and Studies in this project as the expected benefits are for Faridabad City area. The NOC is required for utilizing the government land for construction of recharge structure only. The NOC in this regard is required for a period of three years only to MRIIRS for execution of said project (representation of MRIIRS is attached for reference).

Sh. Arbind Kumar
Deputy General Manager (E)
Faridabad Smart City Limited, Faridabad

CC: -

1. Ld. CEO, FSCL- for kind information please.
2. Technical Advisor, FSCL- for kind information please.
3. Dr. Aunangshu Mukherjee, Director, CAWTM, MRIIRS.

Chapter for Monograph on "Artificial Recharge to Groundwater and Rain Water Harvesting: Issues and Learning from the Developing Countries"

Combating urban waterlogging with support from underlaying over exploited aquifer: A case study from India

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ABSTRACT

Urban waterlogging and groundwater depletion are two diverse but major challenges of Indian cities under changing climatic conditions. The enhanced extreme events of rainfall in recent years along with rapidly altered hydrological conditions in urban environment pose conducive situation for urban water logging. On the other hand, intense and large withdrawal of groundwater, higher than the natural annual recharge has depleted the groundwater level severely in many Indian cities. A pilot project is executed in Faridabad Smart City of National Capital Region India, to combat water logging and also to rejuvenate groundwater resource.

In the study all steps were undertaken meticulously, beginning from hydrogeological study, site selection, rainfall analysis, calculations of runoff generation, framing well design after identification of suitable recharge zones within depleted aquifer and determination of its intake capacity. It further elucidates estimation of suitable dimension of desilting chamber, fixing suitable dose of ferric chloride for coagulation and assessment of recharge volume. The constructed recharge system is tested whether it is working effectively as per the feedback obtained from independent sources. It has high scalability in similar hydrogeological situation in other parts of India.

Key words: Faridabad, Groundwater, Over-exploitation, Recharge, Flash food**,** Urban hydrogeology

1. INTRODUCTION

Incidence of prolong water logging in areas of cities and towns are increasingly reported worldwide and particularly from India in the light of changing global climate. There are several origin of such urban water logging creating frequent threat for infrastructure damage, economic loss and social unrest (*Chen et al 2021, Roy et al 2021, Wei et al 2020*). Environmentalist and town planners are looking for effective interventions. On the other hand, several Indian /world cities are hugely dependent on groundwater source for meeting up their daily requirement of water (*Howard and Israfilov 2002, Schirmer et al 2013,Casanova et al 2016,Saha et al 2018*). It exerts unprecedented stress on the under lying aquifers.

India is critically dependent on its aquifers, with an annual groundwater extraction, as per the latest estimation, as 244.92 billion m^3 (*CGWB 2021*), which is currently world's highest annual draft from a single country. As a result, in India nearly 16% groundwater assessment units are categorized as *over-exploited* where annual draft exceeds annual dynamic groundwater recharge. Large part of these over-exploited units is concentrated in the north & north-western parts of the country and also in the south & south-eastern states of country **(Fig. 1** *CGWB 2021*). Further, nearly 20% of the other assessment units are grouped under *semi-critical, critical* and *saline* category. Therefore, only 64% of assessment unit are still remained under *safe* category having less than 70% extraction of annual dynamic recharge. Many of them are even potentially low in groundwater resources. The distribution of *over-exploited* assessment units shows that the aquifer underlying them are largely alluvial in nature in the northern and north western parts of India and occupied lithologically by deposits of Quaternary age. Due to excessive irrigational and domestic extraction, groundwater level in these *overexploited* units have depleted severely. To overcome such an environmental challenge, rainwater harvesting

and artificial groundwater recharge has been practices as supply-side intervention along with demand-side interventions like, crop rotation, crop diversification, behavioural change and adopting improved irrigation technology.

The paper highlights the pilot project on artificial recharge of the depleted aquifers in the Faridabad urban area. The city suffers from water logging during monsoon, the frequency of which has increased due to the climate change. The Pilot Project offers a scalable eco-friendly solution to combat water logging by diverting the water into the underlaying over-exploited aquifers.

1.1 Study Area

The site is located in one over-exploited assessment units i.e., Administrative Block Faridabad of Haryana state, India. The intervention site is located at Officers' Colony of Sector-15A, Faridabad (28°23'45.50"N, 77°19'6.96"E, 53H/7). The Colony is having 3.25-hectare open area. Geo-morphologically the Faridabad area is represented by alluvial plain, bounded by residual hills of Aravalli in the west and the Yamuna River (flows from North to South) in the East. The regional slope of the area is towards south-east. The elevation of the area is 201m

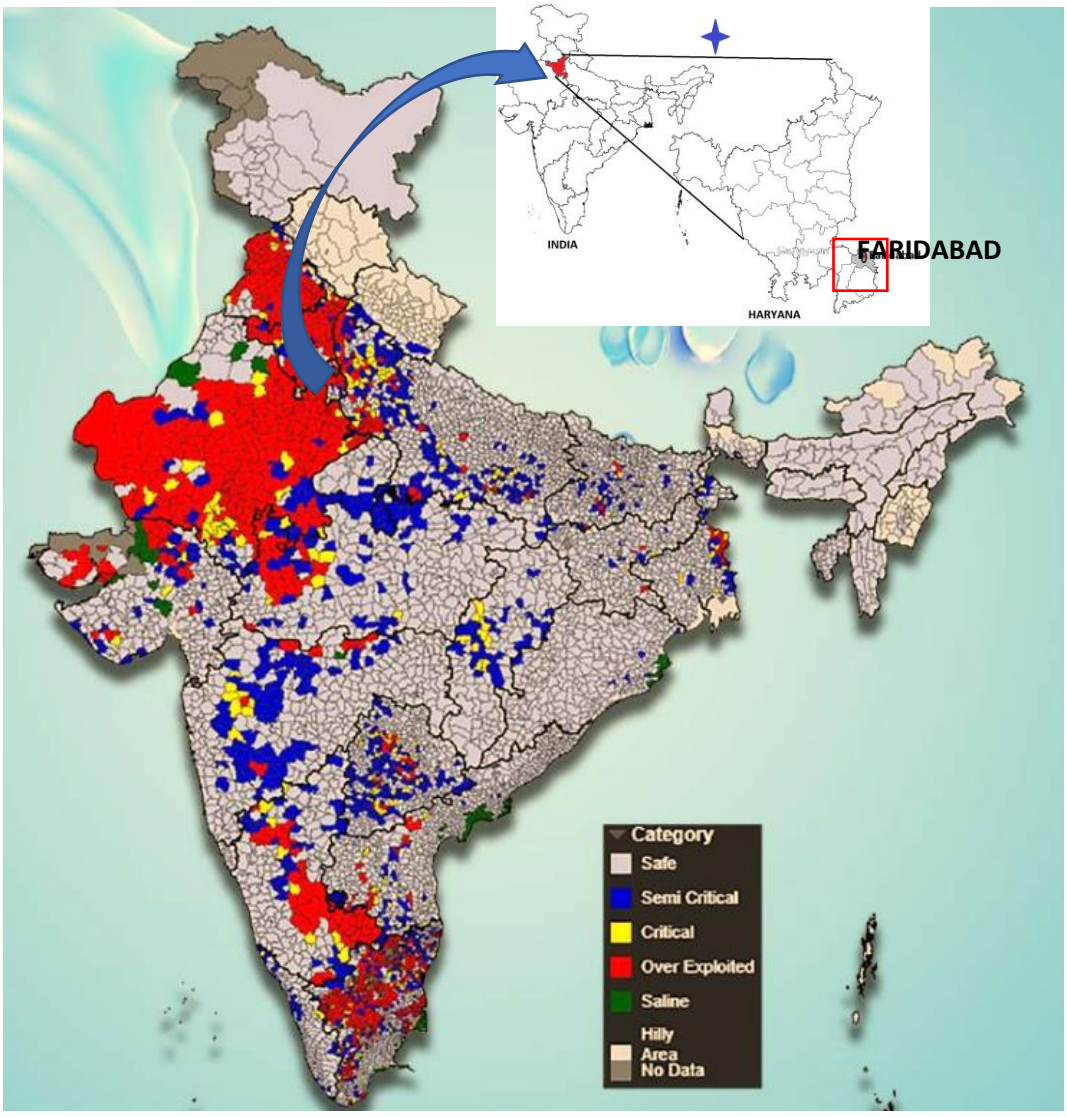

Fig-1 Location map of study area with groundwater over exploited units in India in red

above mean sea level (msl). Geologically, the area is occupied by Quaternary Older Alluvium. which is having a thickness of over 200m underlain by quartzite of Alwar Group, Delhi Super Group (Palaeo-Proterozoic age) (Ref?).

IN Faridabad urban area the settlements are aligned along the north-south running railway line, Agra-Gurugram canal and National Highway (NH-19). The spread of township is also constrained by the Aravalli ranges in the western side and the Yamuna river in the eastern side. The population density along the NH-19 is higher and gradually reduces towards eastern and western side.

2. METHODOLOGY

To investigate the water logging and its cause at the same time the condition of the aquifers underlying in the study area, following investigations were carried out: -

1. Analysis of long-term, short-term and daily Rainfall
2. Calculation of runoff generating from rooftop area, paved area and open/green area of colony.
3. Estimation of dimension and construction of de-siltation and coagulation chambers.
4. DGPS survey of Colony area to locate pinpoint site for the structure.
5. Surface geo-physical investigation to generate first-hand knowledge about the geometry of aquifer.
6. Drilling of pilot hole by rotary method, preparing litho-logs, examining the sediments
7. Borewell geo-physical logging applying short normal, long normal and self-potential resistivity to confirm the lithological log prepared.
8. Detail design of the recharge well and the filter material
9. Development of the well to make it mud free and construction of the well.
10. Sludge test for determination of well performance and aquifer properties.
11. Computation of quantum of recharge and rate of recharge as per actual field conditions during Monsoon.

3. HYDROGEOLOGICAL AND HYDROLOGICAL SETUP

The study area is underlain by unconsolidated aquifers with predominant primary porosity. Lithologically, the Colony area in particular is underlain by silty clayey sand, silty sand, clayey silt and medium sand with silt up to 60m depth. The silty clay sand prevails down to 21m and a clay horizon occurs between 33 to 36mbgl. The litholog made from the drill cut samples and the sub-surface geo-physical log is given in the **Fig.2.**The annual water level in the Colony area is below 50m. The Transmissivity of the aquifer ranges between 145 and 875 m^2 / day and the storativity ranges from 1.03× 10-5to 3.85 ×10-5. The discharge varies from 1060 to 2300 lpm with a drawdown of 4 to 40m (*CGWB 2015*).

Upper part of the lithological section in the study area is clay and thus acts as an aquitard. This aquitard prevents infiltration of runoff and promotes water ponding in the area. The Colony area is located in the densely populated part of the city and having higher paved area/ rooftop those further reduces infiltration. Thus, geogenic and anthropogenic factor together create a conducive condition for water logging. Further due to changing climatic conditions extreme events of rainfall have increased in recent years. Hydrogeologically, the aquifers in the area

remains under semi-unconfined to confined condition where stage of groundwater development remains as > 100%.

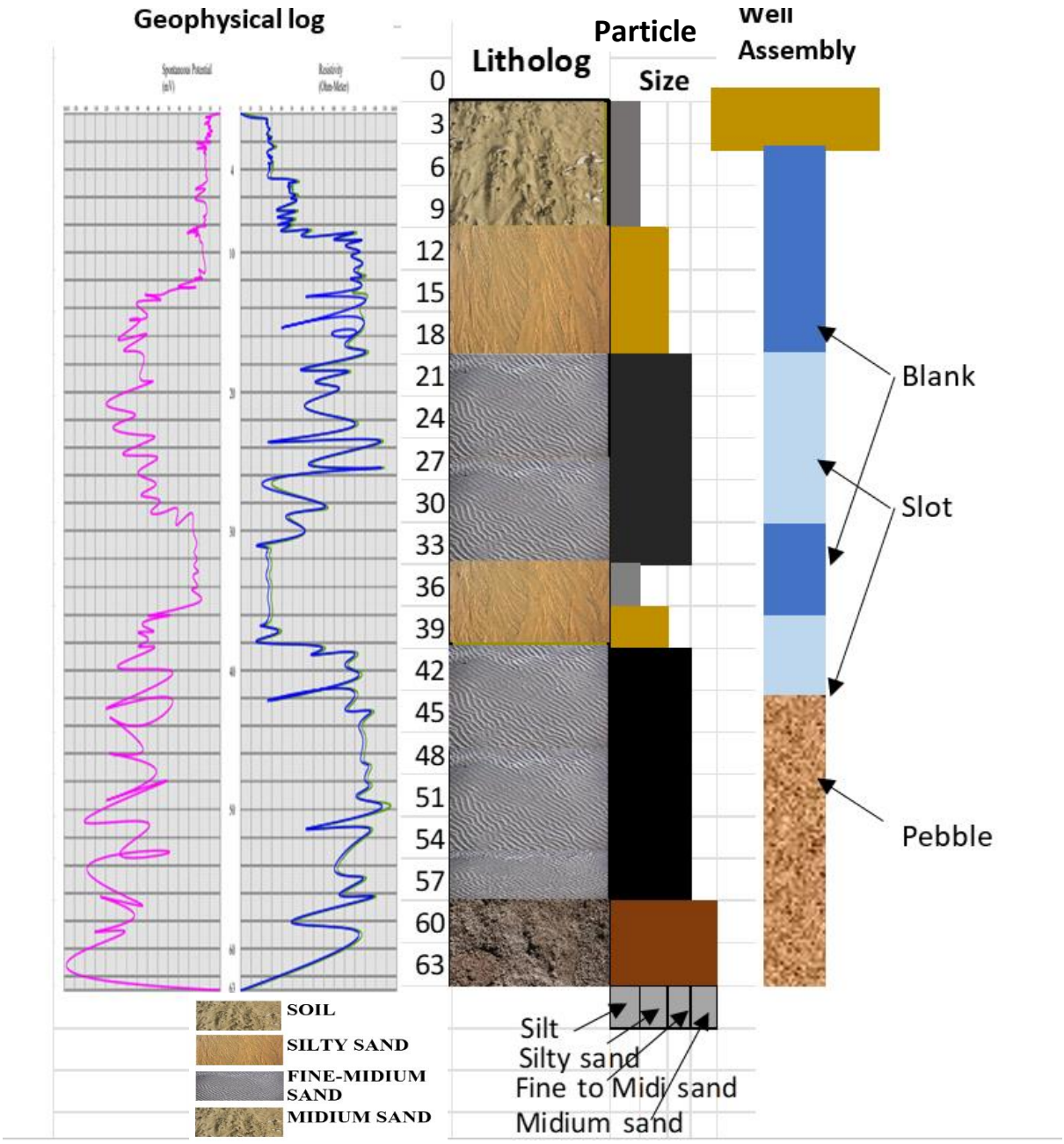

Fig 2. Composite graph of bore hole geophysical log, lithology, grain size and well assembly.

3.1 Depth of Water Level

Water level within the City area and in the adjacent parts of the Faridabad block varies between 20 and 77m bgl.. The DTW map (**Fig. 3)** clearly depicts that the deepest water levels are observed within the township area of Faridabad, along the National Highway. The levels gradually become shallower in the east and west side. In the < 3m zone, the water level however

remains between <1 and 2.75m bgl. Further, area having water level between 3 and 10m bgl is observed surrounding < 3m zone. Largely in the Aravalli hills area, water level is found between 20 to 40m bgl, whereas along the River Yamuna, it varies from 10 to 40m bgl during pre-monsoon period. Deeper groundwater level, > 40m bgl occurs in the central part of the township in an elongated stretch in north-south direction (up to Gurgaon canal) and then the alignment turns towards south-eastern direction between Ballabhgarh and Dayalpur. In three detached patches deepest-water level (>60m bgl) have been identified, around Sharma colony, Asian hospital, and Sector-70 **(Fig. 3).**

3.2 Groundwater Flow Map

The water level contour map reveals formation of groundwater trough along the north-south aligned National Highway, extending towards the Dayalpur area. It also reveals recharge from Aravalli hills and flow from waterlogged area (along Yamuna?) towards the central trough. In regional scale groundwater flow direction is towards the Yamuna River but locally within the city area, it has been totally altered. Recharge of groundwater from river Yamuna towards the central trough zone can be seen (**Fig. 4**).

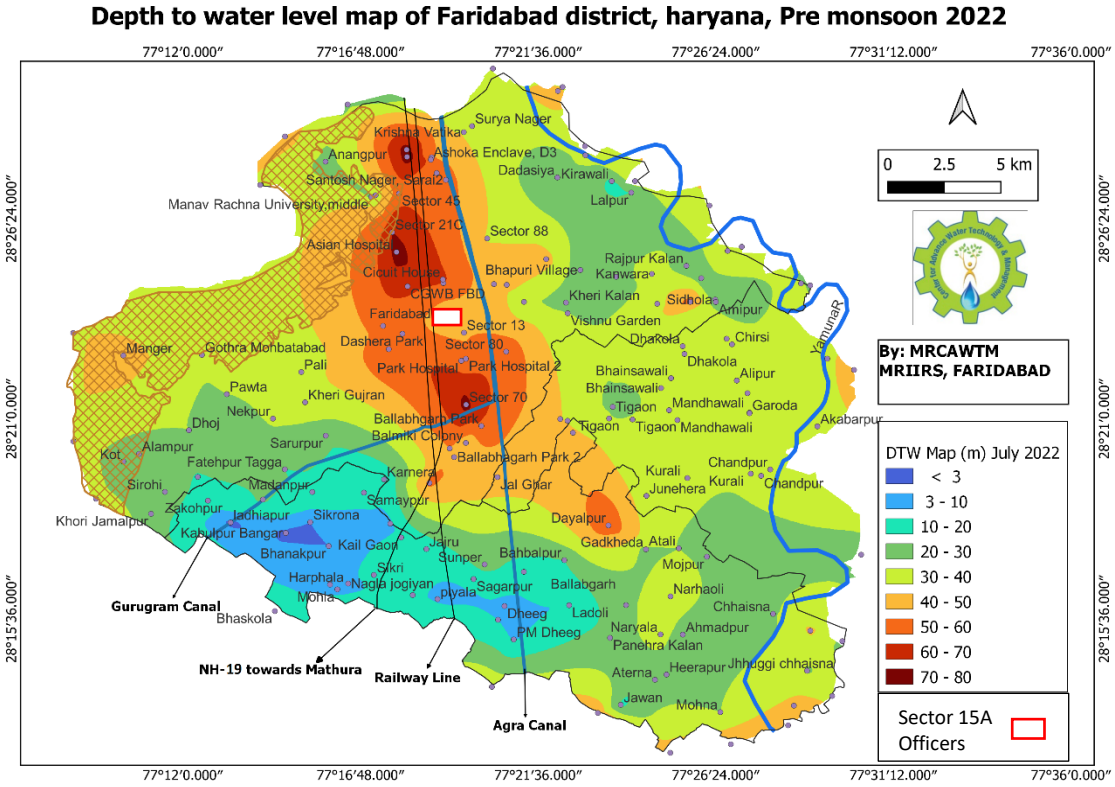

Fig 3. Depth to water level map of Faridabad district, Pre-Monsoon 2022

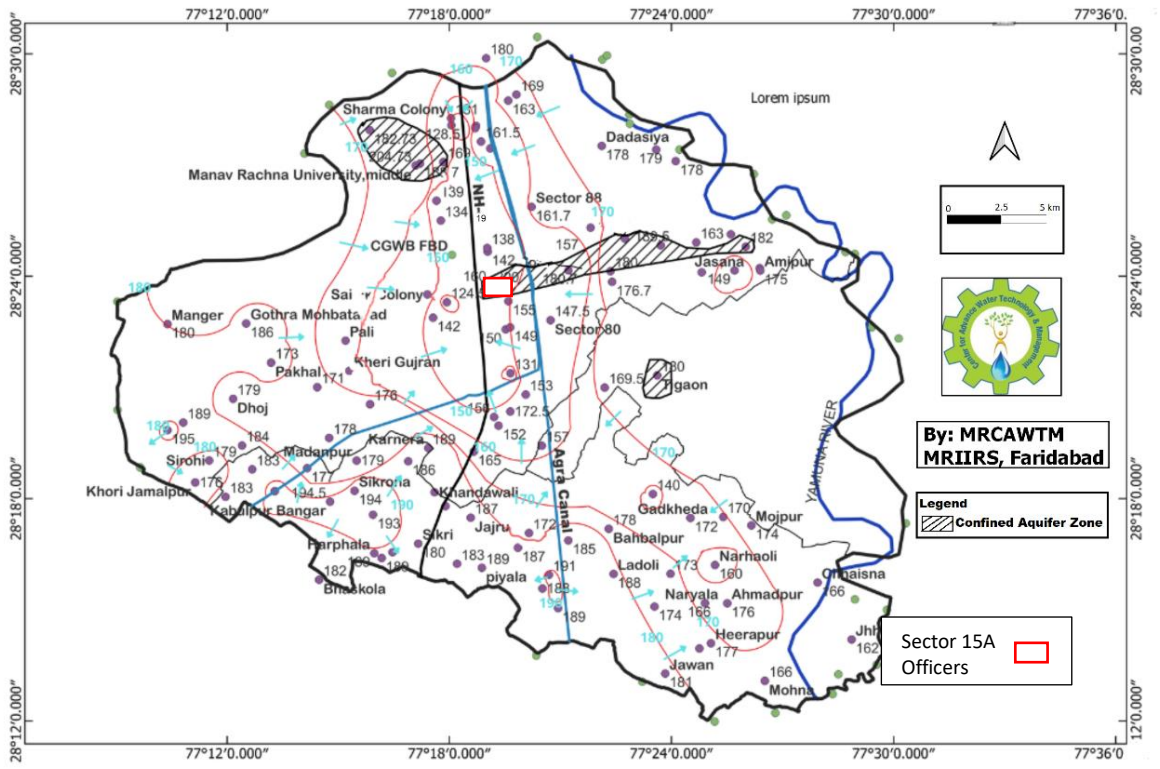

Fig 4. Water level contour map of Faridabad district, Pre- Monsoon 2022

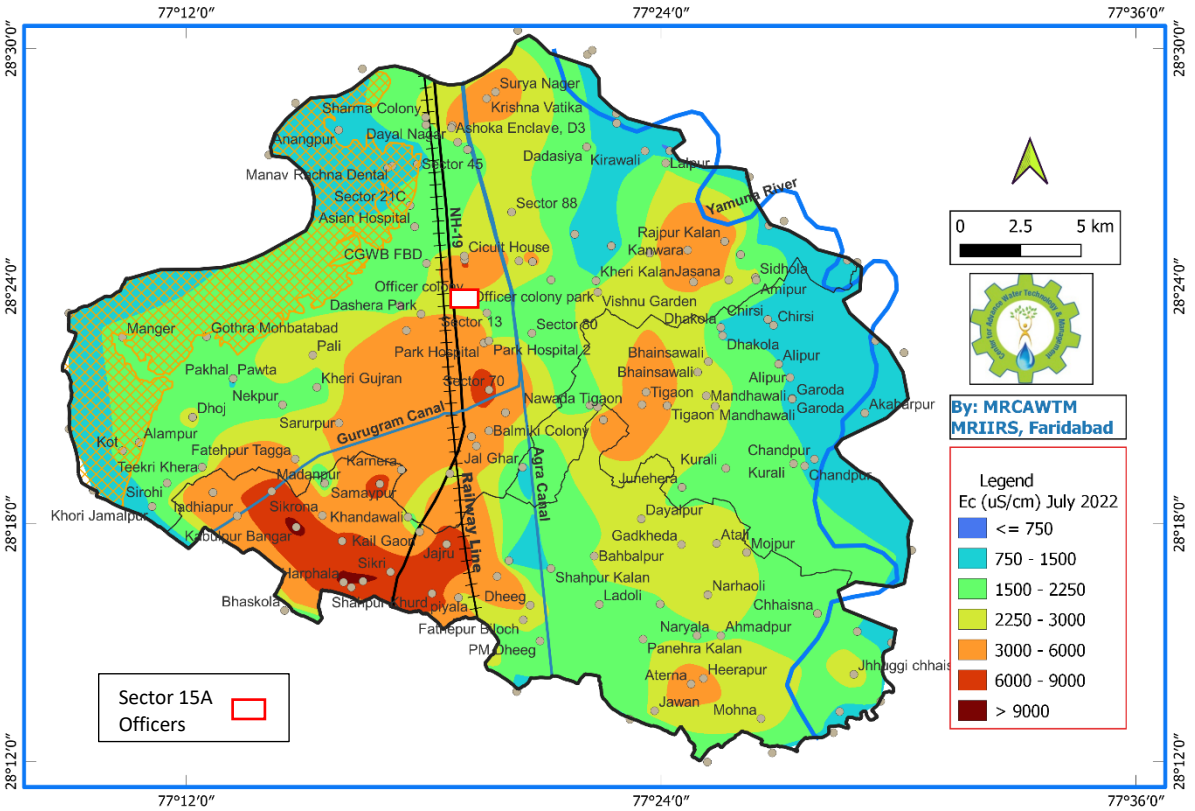

Fig 5. Electric Conductivity map of Faridabad district, Pre-Monsoon 2022

3.3 Distribution of Electrical Conductivity

It has been observed, largely the electrical conductivity (EC) of groundwater remains within 1500 µs/cm **(Fig 5)**, however concentrated high EC zone has been found around shallow groundwater level area EC 2250 to > 9000 µs/cm)..

The Figs. 3,4 & 5 reveal that due to the formation of central trough along National Highway the groundwater movement is directed towards the central trough. Since the south-western part is predominantly having higher EC, therefore along with the groundwater flow the high EC plume started migrating towards north-east direction. The salinity has been aggravated due to over exploitation and a zone of 1500 to 2500 µs/cm of EC is created covering large area of the southern side of central trough. However, after Gurgaon canal turn towards Dayalpur the EC is < 1500 µs/cm, indicating recharge from Yamuna. The situation is alarming as not only there is possibility of drying up of aquifers along the National Highway but also the water quality will deteriorate rapidly unless corrective measures are taken.

3.4 Rainfall Analysis

Faridabad area falls under semi-arid region, and monsoon generally strikes around 1st week of July and retrieves around mid-October. Long term trend shows marginal decline in annual rainfall in Faridabad- NCR area (**Fig 6**). To understand the impact of changing climate, long and short-term meteorological data were analysed to find out the changing patterns of rainfall and temperature indices (*Chauhan et al, 2022)*. Further recent analysis by IMD of past 30 years data (1989 to 2018) shows Faridabad district having 29 to 34 rainy days with annual mean of 618.8 mm (*Guhathakurta et al, 2020)*

Rainfall data of 2020 and 2021 were collected (ref?) from a station located at 2.25km from the site(**Fig 7)**. It has been observed that the daily rainfall remains by and large around 25mm/day, and occasionally up to 60mm barring occasional extreme events.. Extreme events were observed thrice in a year when rainfall crossed 80mm/day mark and have even exceeded 140mm/day in 2021.

This rainfall analysis data was used for calculating the potential runoff generation as given in the table Based on the rainfall data it has been calculated that from 3.25-hectare area of Officers' Colony, maximum 2000m^3 (**Table 1**). water per day can be generated (**Fig 8**). For computing the dimensions of de-siltation chamber (considering the mean grain size of the sediments) and considering the LULC pattern, the various categories of runoff generation has been tabulated below (Table 1).

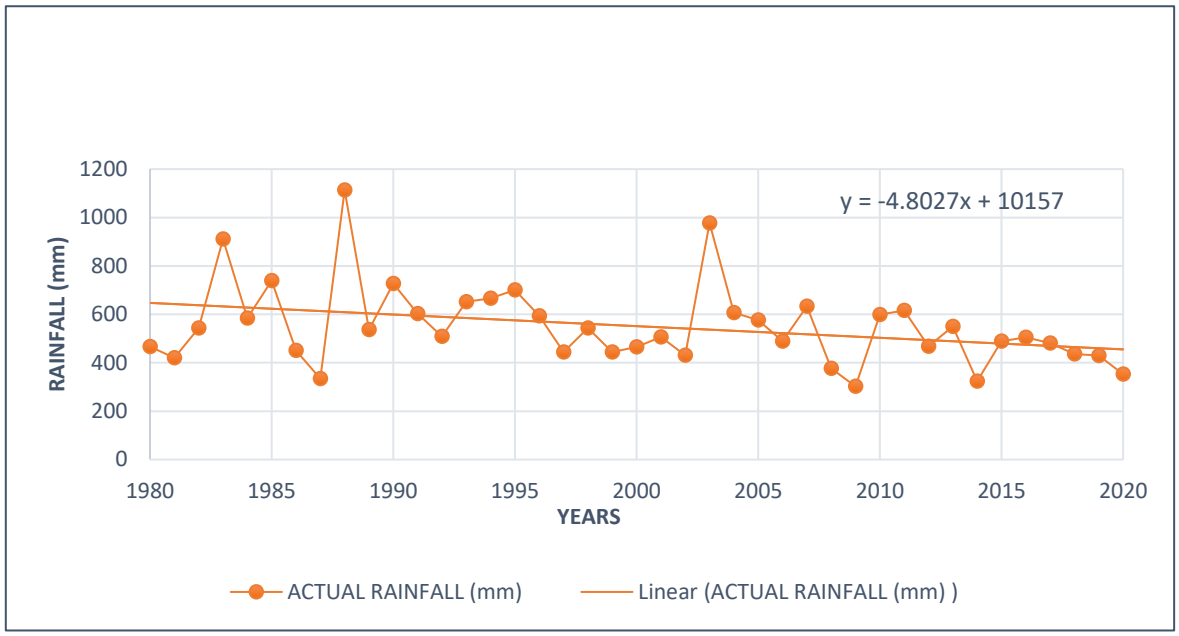

Fig 6. Long term rainfall analysis of Faridabad (1980-2020)

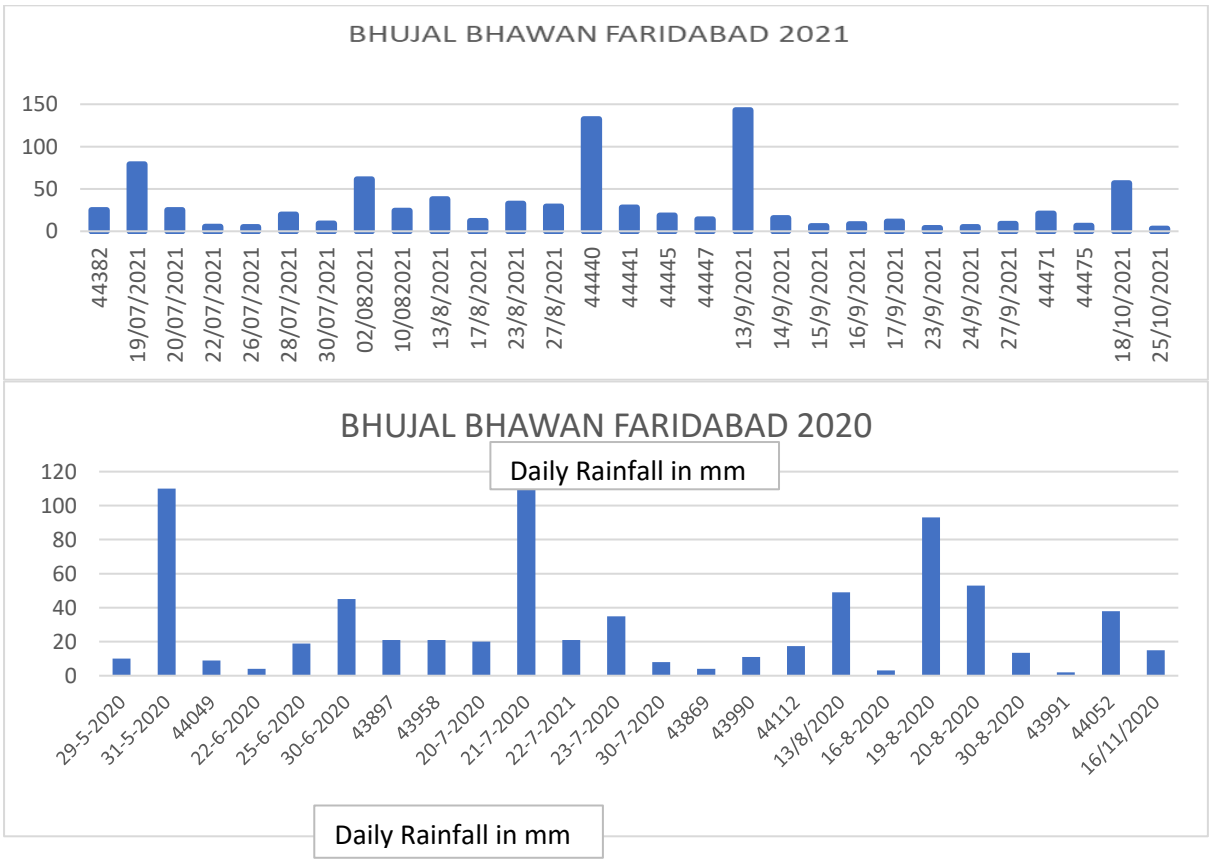

Fig 7. Analysis of daily rainfall data of Faridabad city for two years (2020 and 2021)

Table 1 Computation of runoff from Officers Colony, Sector 15A, Faridabad

SN	Rainfall in m	Roof Area runoff @80%	Paved Area/ runoff@65%	Green Area / runoff @15%	TOTAL ham	Runoff m3
Area in Ha		0.75	1.65	0.85	3.25ha	-
Annual Rain fall	0.6	0.36	0.6435	0.0765	1.08	10800
Normal per day Rain fall	0.025	0.015	0.0268125	0.0031875	0.045	450
General Rain fall/Day	0.061	0.0366	0.0654225	0.0077775	0.1098	1098
Maximum Rain fall/Day	0.11	0.066	0.117975	0.014025	0.198	1980

Fig 8 Google Earth Image showing location of construction in Officers colony, Faridabad

3.5 Magnitude of Water logging

The entire area of Sector 15, and 16 and large parts of Sector 19, 21, 22, 23and 28 of Faridabad experience water logging during high rain event (>40mm/day). The water remains stagnated for several days and creates immense difficulties for the citizens, traffic jam etc. It is estimated nearly 17km2 area of Faridabad City gets frequent water logging (**Fig 9**).

Fig 9 Photographs of actual waterlogging in some locations of Faridabad and of Colony area.

3.6 Calculation of Dimension for Desilting Chamber

As the area is having silty clay/clay at the top, therefore, it has been considered that substantial runoff will be generated with considerable suspended and colloidal material. To prevent this suspended and colloidal load to move towards the recharge well, treatment chambers are

constructed. Finally, the treated water pass through sand filter for around the recharge well. The dimension of desilting chamber has been calculated as below (**Table 2**).

Table 2 Desilting chamber dimensioning & Hydraulic calculations

Discharge Q	*Normal/day*	450	m3		
	Max/day	2000	m3		
	Annual	11000	m3		
Size of sediment particles say			<0.0020	mm	
Settling velocity through Desilting Chamber (DC)					
*Vs = C*d2*			0.0358	m/s	
Consider particle size to be settled 'd'			0.0010	mm	
Settling velocity thru DC, Vs=			0.00895	m/s	
Flow-through velocity < Critical Velocity					
*Critical velocity Vc=a*sqrt(d) ; a=44 constant*			1.3914	cm/s	
Let us consider Flow through velocity V			1.30000	cm/s	
		=	0.01300	m/s	
(Considering max ppt of 2000 m3/day, we assume av. rain fall duration of 4 hrs)					
Precipitation / hr			500.000	m3	
Peak / Design Discharge			0.1389	m3/s	
Velocity thru DC for Qmax will be governed by the size of outlet to CC					
Required Cross sectional area of outlet			0.107	m2	
Providing 2 nos. circular pipes with dia d =			0.300	m	
*Area of cross section A=2*Pi*d2/4*			0.141	m2 **>**	0.107
Provide Free board			0.300	m	
Total height of chamber			2.000	m	
Center of pipe from bottom of chamber			1.550	m	
Depth of chamber for silt deposition					
Dead storage			1.400	m	

Length of DC is taken as 6.5 m and hight as 2.0 m
Width of DC, W = V*D/Vs

Where; W	=	Width of DC		
V	=	0.0130	m/s	(flow through velocity)
D	=	1.700	m	(depth for settlement)
Vs	=	0.00895	m/s	(settling velocity)
Width	=	**2.46927**	m	

Finally, the dimensions of desilting chamber :

Length	6.50	m
Width	2.50	m
Height	2.00	m

Fig 10. Photographs of constructed desilting and coagulation chambers and dug cum recharge well at Officers Colony.

4. DESIGNING THE RECHARGE SYSTEM

The pinpointing of site was done based on results of surface geophysical investigations - resistivity profiling and sounding and DGPS survey of the campus.

4.1 Construction of Civil Structures

A dug cum recharge well structure is adopted (**Fig 10**). A a 60m deep and 200mm dia pilot hole was drilled first by using a rotary rig. Bore hole logging was carried out when long normal, short normal and self-potential logs were generated for 60m deep pilot hole (Fig 2). The groundwater level in the area is observed around 50m bgl thus deliberately the screen is kept down to 45m bgl only (Fig 2) and the lower 15 m is backfilled with 6-10mm size pea gravel. Then the annular space between 150mm screen and 200mm pilot hole is gravel packed. After completion of lowering of assembly, well was developed with compressed air and over pumping. A 3.0m dia and 3.0 deep dug well is constructed around the recharge well and filled with 2.0m thick filter bed. The filter bed is made of 1.0 m thick bottom pebble, 0.5m thick gravel and 0.5m thick top coarse sand so as to keep 1m blank space for water. About lower1.0m screen of the recharge well within dug well section is kept slotted for entrance of filtered water. A small gutter is created in front of desilting chamber for bringing water to the system. The desilting chamber (6.5*2.5*2m) is having a baffle wall of 1.4m hight to restrict courser material and slow down the velocity of water entering the system. The de siltation chamber is connected to coagulation chamber (3*2.5*2.5) through a 150mm dia inlet pipe from 1.0m below the top of chamber and out let at 1.5m below top. Both the chambers were provided with air vent, steps and cleaning opening. A slab was casted over the system to cover. The coagulation chamber is dosed with ferric chloride as coagulation agent.

4.3 Establishing Well and Aquifer Efficiency

To know the intake capacity of the recharge well, slug tests were performed twice, first with 320m^3 water and then with 450m^3 water (**Fig 11**). It is calculated that intake capacity of the well is 10m^3/minute. Therefore, even with 110mm/day rainfall, about 2000m^3 of runoff can easily been accommodated within the system.

Fig 11. Photograph showing slug testing arrangements at Officers colony, Faridabad

5. DISCUSSIONS

The urban flooding is caused by a combination of factors which is getting, aggravated due to climate variability, overburdened drainage, unregulated construction, no regard to the natural topography, drainage and hydrogeology all make urban floods a man-made disaster.

The rapid urbanization and related paving of open lands by concretization and road construction has aggravated water logging problems in many cities in India and World. Roads and streets of cities during heavy down pour profoundly overflow and mix with sewage and storm water, contaminate the soil and water also. In the older parts of the cities in India, where drains and sewerages constructed decades back; many-a-time unable to carry the enhanced load, faces such a situation commonly with heavy rainfall. Such water logging problems are more acute in low lying areas of the cities (*McCartney &Smakhtin, 2010*)

Faridabad City (Haryana) in the back yard of capital city of India is no exception to such problem. Municipal Corporation of Faridabad (MCF) responsible for water and sewage amenities of the city has, to face such water logging related issues every year, particularly in the Older Faridabad Constituency area. Now, part of the Older Faridabad Constituency area is covered under Faridabad Smart City Project. Water supply of the entire Faridabad urban area is totally by groundwater (*Faridabad Development plan-2031, 2016*). This has resulted in continuous decline (Fig 3 & 4) in groundwater level (*Mukherjee and Shekhar, 2016, Ibkar et al 2022*). The city area is categorized under *Over-exploited* (Fig.1).

The above-mentioned problems of Faridabad city are deteriorating the environment and create potential health risk for the citizens. Technological interventions addressing these water issues

can provide solution to eradicate the water logging problem as well as address the need of Artificial Recharge of groundwater (*Anke Steinel 2012, Chadha, 2014, , Dillon 2005, Pavelic et al 2015, Tuinhof et al 2005*) to minimize the potential health risk to the citizens of Faridabad and improve the amenities of Faridabad Smart City.

The present pilot project is an attempt towards sustainable and eco-friendly solution to these problems. Fast depleting groundwater levels in urban area is imposing water security challenges. Intervention through action research has been taken up to demonstrate to the local authorities a solution to combat the water logging and groundwater depletion (**Fig 12**) through a single intervention.

5.1 Source Water Availability and Suitability

The storm water is used as source water needs pretreatment to meet the requisite quality criterion for recharge. Removal of silt, colloidal particles and dissolved pollutants using a de-siltation method, coagulation process in conjunction for removing settle able particles, is being practiced in several countries (ref?).

An investigation has demonstrated that coagulation by adding ferric chloride is an effective method to reduce the turbidity, though it depends on pH, temperature and flow rate. 85-98% reduction of turbidity from raw water can be achieved by using the optimum coagulant dosage (8ppm) of ferric chloride in the optimum pH 9.2 at a temperature 20°C, (*Koohestanian, et al 2008, Mohammed, 2015*). The primary disadvantage of clogging is that it leads to reduced infiltration over time.

5.2 Identification of Suitable Recharge Zone

The analysis of lithology, result of bore hole logging and slug test shows that the zone between 21 and 33 m depth is suitable for recharge and can be designated as zone -1. Similarly zone between 40 and 60m (Fig 2) can be considered as zone-2 . As the groundwater level is below 50 m in this area, slotted casing is lowered down to 45m depth so that the recharge water can be released into the unsaturated zone. The advantages are, -1) rate of vertical infiltration is higher than horizontal so more recharge would take place 2) any suspended particle if still left in the source water will pass through the unsaturated zone and further filtered. The zone 1&2 together can absorb about $10m^3$/min.

5.3 Effectiveness of Constructed Recharge System

After completion of all constructions of the recharge system, two heavy rainfall episodes occurred in the area on 30th Aug and 22-23rdSept 2022 (74mm and 150mm rainfall) . On both the occasions, the system worked very well and the water logging of the Colony area was cleaned within 3 to 5 hrs and no water was noticed over filter bed around the recharge well then after. Several residents of officers' Colony has given positive feedback about the working of the system.

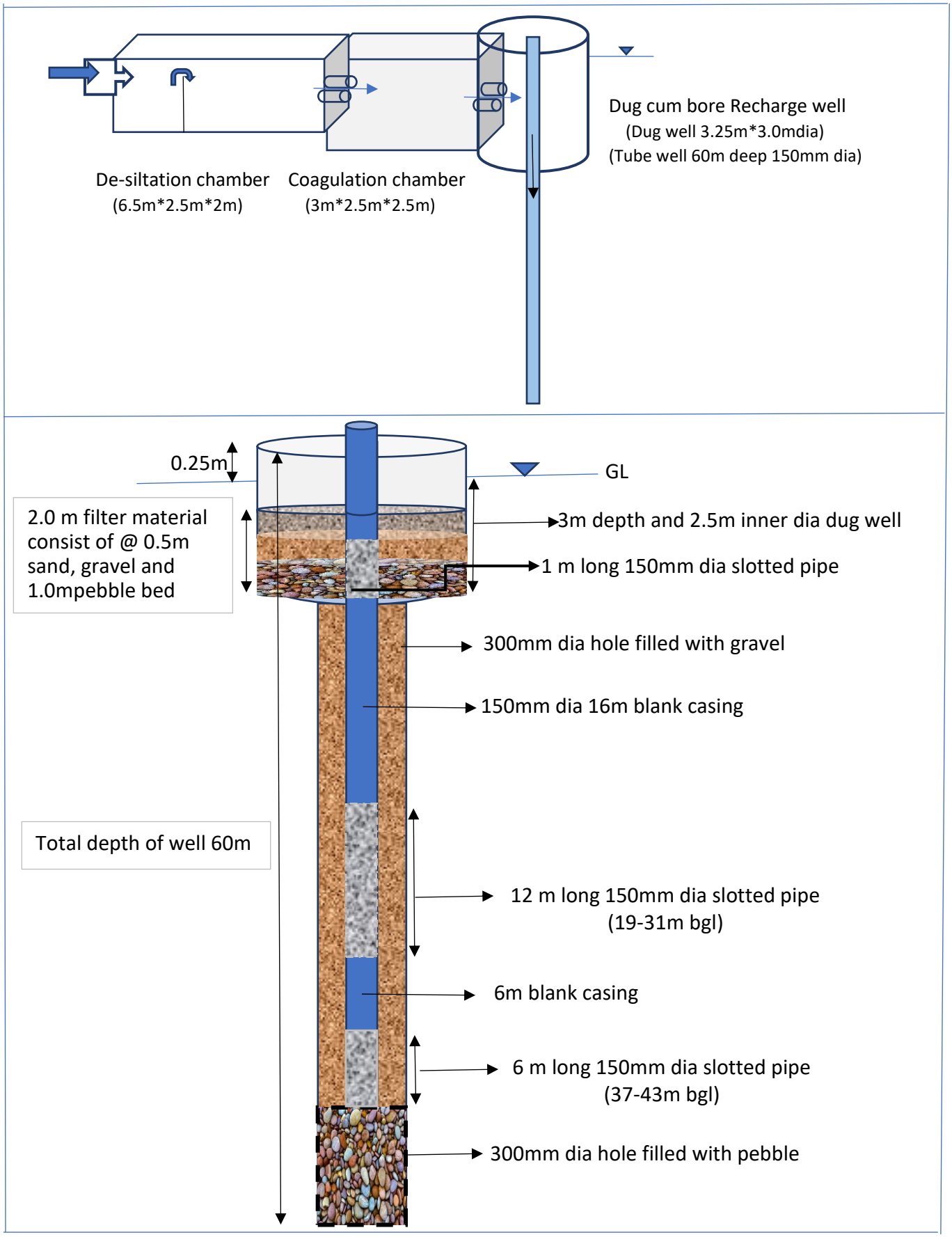

Fig 12 Design of groundwater recharge system at Officers Colony, Sector 15A Faridabad

6. CONCLUSIONS

The water logging in Faridabad City area is combined effect of near surface lithological condition and urbanization related concretisation and pevmentisation. The water logging is aggravated by climate change. The area is categorized as over-exploited and current rate of groundwater depletion is estimated nearly 1m/yr. These are underlain by a two-tier aquifer system. The top aquifer (21-33mbgl) has gone dry as the present groundwater level is > 50m bgl. It has been estimated maximum 2000m^3 runoff can be generated with about max. 110mm/day rainfall from the 3.25ha study area. The cumulative intake capacity of the recharge well (150mm dia 60m deep) tapping12m and 20m thick two recharge zones, is found as 10m^3/minute Calculations indicate for suspended load generates from silty-clay surface with max 2000m^3per day runoff, a 6.5*2.5*2m size desilting chamber is required and for further coagulation 8ppm dosing of $FeCl_3$is enough in a 3*2.5*2.5m size coagulation chamber. A sand filter of 0.5 m thickness around the recharge well is further able to attenuate remaining particles before water finally enters the recharge well. To minimise coagulation of casing slot of well, the bottom of casing is kept open to a 15m thick back filling gravel zone below the well assembly within the drilled pilot well. The system is tested and found working efficiently during two consecutive rainfall episodes of 74mm and 150mm per day. The designed system is having high scalability within the Faridabad Smart City area and in the other townships in similar hydrogeologic framework.

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