भारत सरकार
Government of India
जल शक्ति मंत्रालय,
Ministry of Jal Shakti,
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
Department of Water Resources,
River Development and
Ganga Rejuvenation

केंद्रीय भूमि जल बोर्ड
Central Ground Water Board

NAQUIM 2.0

Sustainable Springshed Management in Dhalai Dist. of Tripura

त्रिपुरा के धलाई जिले में स्प्रिंगशेड के चिरस्थायी प्रबंधन

राज्य एकक कार्यालय, अगरतला, त्रिपुरा
STATE UNIT OFFICE, AGARTALA, TRIPURA

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(NAQUIM 2.0)

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DEPARTMENT OF WATER RESOURCES, RD & GR
केंद्रीय भूमि जल बोर्ड
CENTRAL GROUND WATER BOARD

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Sustainable Springshed Management in Dhalai Dist. of Tripura

प्राथनमकता प्रकार: प्रमुख स्रोत के रूप में स्प्रिंग जल-स्रोत
Priority Type: Areas with springs as the principal source

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मार्च, २०२५ / **March, 2025**

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भारत सरकार
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जल संसाधन,
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Message

National Aquifer Mapping and Management Programme (NAQUIM) was initiated by Central Ground Water Board (CGWB) in 2012 with the goal of mapping and managing aquifers across India to promote sustainable groundwater use. So far, the entire mappable area of 25 lakh km^2 has been covered under the NAQUIM programme. While these initial efforts have been highly impactful, they faced certain limitations, especially in terms of spatial resolution.

Taking it forward, CGWB has now initiated **NAQUIM 2.0**, the next phase of aquifer mapping designed to provide a deeper, more detailed understanding of India's groundwater systems. During 2024-25, CGWB had completed NAQUIM 2.0 studies in **39 Study areas**. The study areas were selected in consultation with the State/UT government agencies.

I am confident that this report of NAQUIM 2.0 study will serve as a critical resource for government agencies, research institutions, NGOs, and the general public. By fostering a collaborative approach to groundwater management, this report will play a key role in safeguarding and sustaining India's precious ground water resources.

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Government of India
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Foreword

Spring water is the accessible and dependable source of water in the hilly region and sustainable management of this vital resource is essential for socio-economic development and overall welfare of human life. Water scarcity is increasing day by day due to population growth, urbanization, agricultural development, industrialization and climate change affecting the rainfall pattern etc. In hilly areas, acute water shortage is experienced during summer mainly due to physiographic set-up and geology. Hence, it is very important to formulate a strategy to achieve water security for drinking water needs.

The report on "***Sustainable Springshed Management in Dhalai Dist. of Tripura***" has been prepared with an attempt to suggest strategies and management plan to mitigate the water scarcity of the study area based on ground water resources potentials, geological and hydrogeological set up, ground water quality aspects, annual rainfall etc. The report includes the scientific approach for augmenting yield of springs by adopting suitable interventions, roof top rain water harvesting and harnessing potential springs.

The effort of Dr. Raja Ram Purohit, Sc-D, SUO Agartala, CGWB in bringing out the report is highly commendable. The efforts of the officers of Central Ground Water Board, SUO, Agartala and NER in preparation of the report are highly appreciated.

It is hoped that the report will be of immense benefit to the planners, policy makers and geo-scientists who are concerned with the onerous task of sustainable development and management of ground water & springs in the hilly terrain, specifically in the North Eastern State of India.

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Government of India
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Central Ground Water Board

Preface

Spring is an important source of groundwater and plays a significant role in meeting the water requirements in the hilly areas. In the recent years, this vital source is under threat due to human activities, growth in population and climate change.

Central ground Water Board carried out study on Springs (under NAQUIM 2.0) to study the prospect of Springs and to provide information for sustainable management of the spring water at ground level.

This report aims to provide a comprehensive and holistic picture of spring water sources covering geomorphological, geological and hydrogeological conditions, available ground water resource, development prospects, ground water contamination etc. Present water scenario indicates that there is a shortfall in drinking water supply. To mitigate the demand and for providing adequate water supply, a management plan has been suggested which includes augmenting yield of ground water, roof top rain water harvesting and harnessing potential springs. For augmenting yield of ground water through the springs, areas have been identified for adopting suitable interventions.

The sincere effort put forth by the team of Scientists from SUO Agartala, Tripura (Dr. Raja Ram Purohit, Sc-D & Ms. Ritu Kumari Oraon, Sc-C) and the other associated officers from NER Guwahati in collection of field data and preparation of this report titled, "*Sustainable Springshed Management in Dhalai Dist. of Tripura*" is highly appreciated.

It is hoped that the report would be of immense help for the planners, policy makers, Government departments and administrators of the State who are engaged in planning, development and management of ground water resources.

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कार्यकारी सारांश

स्प्रिंगशेड प्रबंधन अध्ययन को प्राथमिकता क्षेत्र 5: "प्रमुख स्रोत झरनों वाले क्षेत्र" के अंतर्गत रखा गया है। राष्ट्रीय जलभृत मानचित्रण एवं प्रबंधन कार्यक्रम (NAQUIM 2.0) के अंतर्गत, लगभग 900 वर्ग किलोमीटर की स्प्रिंग सूची प्रस्तावित की गई थी। ज़िले की उत्तरी सीमा बांग्लादेश से लगती है। यहाँ सामान्य मानसून वर्षा 1,387 मिमी और सामान्य वार्षिक वर्षा 2,530 मिमी होती है।

भौगोलिक दृष्टि से , इस क्षेत्र को दो भागों में विभाजित किया जा सकता है: अपनतीय पर्वत श्रृंखलाएँ और अभिनतीय समतल तल वाली घाटियाँ। भूगर्भीय दृष्टि से, अध्ययन क्षेत्र में चतुर्थक और उच्चतर तृतीयक शैल समूह पाए जाते हैं। इस क्षेत्र में उप-समांतर, धनुषाकार, दीर्घित, द्विध्रुवीय अवतलित वलित शैलें हैं जो एक समांतर पैटर्न में व्यवस्थित हैं और औसतन उत्तर-दक्षिण दिशा में प्रवृत्त हैं। सूरमा समूह की शैलें अपनतीय रेखा के केंद्र में पाई जाती हैं, जबकि युवा डुपिटिला समूह और नवीन जलोढ़ अभिनतीय रेखा के मध्य भाग में पाए जाते हैं।

जल-भूवैज्ञानिक दृष्टि से , घाटी क्षेत्रों में भूजल की अच्छी संभावना पाई जाती है। हालाँकि, तीनों घाटियों - गंडचेर्रा, कमालपुर और मनु - में से गंडचेर्रा घाटी में भूजल की सबसे कम संभावना है। कमालपुर घाटी में, तीन से चार पतले दानेदार क्षेत्र 250 मीटर की गहराई तक फैले हुए हैं। मनु घाटी के उत्तरी भाग में, महीन से मध्यम दाने वाले बलुआ पत्थर की अच्छी मोटाई मौजूद है।

स्प्रिंगशेड के पुनरुद्धार कार्य और दीर्घकालिक निगरानी के लिए एक उपयोग में आसान स्प्रिंग इन्वेंटरी प्रारूप तैयार किया । यह प्रारूप अद्वितीय है क्योंकि इसमें निम्नलिखित मानदंड शामिल हैं: (i) स्प्रिंगशेड का स्वामी, (ii) आसपास की औद्योगिक गतिविधियाँ, (iii) पानी का रंग, (iv) पानी की गंध, (v) आसपास के क्षेत्र में दागों का रंग, (vi) आसपास की सामान्य स्वच्छता और सफ़ाई, (vii) स्प्रिंग पर निर्भर लोगों की संख्या, (viii) पेयजल के वैकल्पिक स्रोत की उपलब्धता, (ix) स्प्रिंग के ध्वस्त होने की संभावना (सड़क और औद्योगिक गतिविधियों से), और (x) स्प्रिंग चैंबर की उपलब्धता और आयाम।

2023-24 और 2024-25 की वार्षिक कार्य योजनाओं (एएपी) के दौरान कुल 38 झरनों और 4 आर्टेसियन कुओं की सूची तैयार की गई। अप्रैल 2023 से मार्च 2025 तक हर महीने झरनों से पानी का निर्वहन मापा गया। मानसून से पहले और बाद के मौसम में पानी के नमूने एकत्र किए गए। कुछ महीनों में मासिक निगरानी छूट गई, लेकिन डेटासेट निरंतर बना हुआ है।

वसंत के जलालेख तैयार किए गए और वर्षा की घटनाओं के साथ उनकी तुलना की गई। गुणात्मक रूप से उनके संबंध को परिभाषित करने के लिए वर्षा के विरुद्ध निस्सरण का आलेखन किया गया। मनु घाटी के झरनों की तुलना चावमानु वर्षामापी केंद्र के वर्षा के आंकड़ों से की गई, जबकि कमालपुर घाटी की तुलना केवीके धलाई केंद्र के आंकड़ों से की गई। लोंगतराई पहाड़ी दोनों घाटियों को अलग करती है। वर्षा और वसंत निस्सरण के बीच एक अच्छा संबंध देखा गया। वसंत का बढ़ता हुआ भाग अप्रैल/मई में मानसून-पूर्व वर्षा के साथ शुरू होता है, और मध्य मानसून के दौरान निस्सरण का चरम स्तर देखा जाता है। वर्षा बंद होने के बाद निस्सरण कम हो जाता है, और अगली वर्षा होने तक धीरे-धीरे कम होता जाता है। 100 मिमी से कम वर्षा का वसंत निस्सरण पर कोई महत्वपूर्ण प्रभाव नहीं देखा गया।

निस्सरण जलालेख, जो एक शिखर से अगले उदय के आधार तक फैला होता है, बिना किसी महत्वपूर्ण वर्षा के समय में अवनति अवधि को दर्शाता है। इस अवनति वक्र के विश्लेषण से झरने के जलभृत की विशेषताओं को समझने, विभिन्न प्रवाह घटकों को अलग करने और कम प्रवाह की स्थिति में निस्सरण की भविष्यवाणी करने में मदद मिलती है, जो इसे स्थायी झरने के जल प्रबंधन का अभिन्न अंग बनाता है। 2023-2024 के झरने के निस्सरण आंकड़ों का विश्लेषण प्रेक्षित वक्रों को मेललेट के समीकरण में फिट करके किया गया। अवनति अवधि के आरंभ और अंत में प्रारंभिक

(Q0) और अंतिम (Q1) निस्सरण मान 2023 और 2024 के बीच समान झरनों के लिए भिन्न थे, जो वर्षा पर निर्भरता को दर्शाता है। 2023 में वर्षा में भारी कमी कम निस्सरण में परिलक्षित हुई, जबकि 2024 में अधिक वर्षा के परिणामस्वरूप निस्सरण में वृद्धि हुई और Q0 और Q1 मान उच्चतर हुए।

कमालपुर घाटी में 15 झरनों के लगभग बराबर है , जबकि कमालपुर में पुनर्भरण ज़्यादा है । इससे पता चलता है कि मनु घाटी का जलभृत ज़्यादा पारगम्य है, जिससे गतिशील भंडार ज़्यादा है, लेकिन समय के साथ इसके झरनों के कम होने का ख़तरा भी बढ़ रहा है।

अध्ययन के दौरान, 13 वर्टिकल इलेक्ट्रिकल साउंडिंग (वीईएस) सर्वेक्षण किए गए। इन सर्वेक्षणों से 1 से 100 मीटर की गहराई के बीच भूजल संभावित क्षेत्रों की पहचान हुई, जिससे भूजल विकास के महत्वपूर्ण अवसरों पर प्रकाश डाला गया। वीईएस अध्ययनों ने पारगम्य से अर्ध- पारगम्य परतों के नीचे एक अभेद्य मिट्टी की परत का चित्रण किया, जो नीचे की ओर जल प्रवाह को बाधित करती है और भूजल को संपर्क-प्रकार के झरनों के रूप में उभरने के लिए मजबूर करती है।

जल गुणवत्ता मूल्यांकन प्रमुख चिंताओं और सतत उपयोग हेतु सुझावों पर प्रकाश डालता है। पीने योग्य जल की उपयुक्तता का मूल्यांकन भारतीय मानक ब्यूरो (बीआईएस) के दिशानिर्देशों के अनुसार किया गया, विशेष रूप से लौह (Fe) और मैंगनीज (Mn) के लिए। मानसून के दौरान अधिकांश झरनों ने बीआईएस की सीमा को पूरा किया, लेकिन कम पुनर्भरण और लंबे समय तक जल-अवस्था के कारण बाद और मानसून- पूर्व खनिजीकरण में वृद्धि देखी गई। कुछ नमूनों में लौह और मैंगनीज अनुमेय सीमा से अधिक थे, जिसके कारण ऑक्सीकरण, निस्पंदन या अधिशोषण जैसी शमन रणनीतियों की आवश्यकता पड़ी। पाइपर प्लॉट व्याख्याओं से भूजल रसायन विज्ञान में मानसून के दौरान कैल्शियम-मैग्नीशियम-बाइकार्बोनेट (Ca-Mg-HCO_3) की प्रधानता से मानसून- पूर्व सोडियम-समृद्ध यौगिकों की ओर क्रमिक परिवर्तन का पता चलता है।

प्रमुख चिंताओं में झूम खेती से भूमि क्षरण, भूमि उपयोग पैटर्न में परिवर्तन (जैसे, सड़क निर्माण), वनों की कटाई, पुनर्भरण क्षेत्रों में दावानल, चराई और अनियमित वर्षा शामिल हैं। प्रस्तावित पुनरुद्धार योजना में सतही प्रवाह को रोकने और जल- रिसाव को बढ़ाने के लिए खाइयों और तालाबों जैसे कृत्रिम पुनर्भरण कार्य शामिल हैं। यह मानवजनित हस्तक्षेप से झरनों की सुरक्षा पर भी ज़ोर देता है । झरनों की स्थिरता सामुदायिक जागरूकता और समय-समय पर रखरखाव एवं निगरानी में सक्रिय भागीदारी पर निर्भर करती है। चूँकि सरकार का ध्यान व्यक्तिगत झरनों पर सीमित हो सकता है, इसलिए ग्राम समितियों का गठन और प्रशिक्षण आवश्यक है।

EXECUTIVE SUMMERY (ENGLISH)

The springshed management study in Dhalai District, Tripura, has been assigned under priority area 5: "Areas with springs as the principal source." Under the National Aquifer Mapping and Management Program (NAQUIM 2.0), a Spring Inventory of approximately 900 sq. km was proposed. The district shares its northern boundary with Bangladesh. The normal monsoon rainfall is 1,387 mm, and the normal annual rainfall is 2,530 mm.

Physiographically, the area can be divided into two parts: Anticlinal Hill Ranges and Synclinal flat-bottomed valleys. Geologically, the study area is occupied by Quaternary and Upper Tertiary groups of rocks. The area comprises sub-parallel, arcuate, elongated, doubly plunging folds arranged in an en-echelon pattern and trending in an average north-south direction. The Surma Group of rocks are found in the core of the anticline, while the younger Dupitila Group and recent alluvium occupy the central part of the syncline.

Hydrogeologically, the valley areas are found to have good groundwater potential. However, of the three valleys—Gandacherra, Kamalpur, and Manu—the Gandacherra valley has the least groundwater potential. In the Kamalpur valley, three to four thin granular zones extend down to a depth of 250 m. In the Manu valley, a fairly good thickness of fine to medium-grained sandstone horizon is present in the northern part.

The study devised an easy-to-use spring inventory format for future springshed rejuvenation work and long-term monitoring. This format is unique as it incorporates parameters like (i) Owner of the Springshed, (ii) Industrial activities in the vicinity, (iii) Colour of the water, (iv) Smell of the water, (v) Colouration of Stains in the surrounding area, (vi) General Hygiene and cleanliness of the surroundings, (vii) Number of dependents on the Spring, (viii) Availability of an alternative source of drinking water, (ix) Spring vulnerability to demolition (from Road and Industrial activities), and (x) Availability and Dimensions of the Spring Chamber.

A total of 38 springs were inventoried during the Annual Action Plans (AAP) for 2023-24 and 2024-25, along with 4 artesian wells. Spring discharge was measured monthly from April 2023 to March 2025. Water samples were collected during pre- and post-monsoon seasons. Monthly monitoring was missed in a few months, but the dataset is otherwise continuous.

Spring hydrographs were prepared and compared with rainfall events. Discharge was plotted against rainfall to qualitatively define their relationship. Springs in the Manu valley were compared with rainfall data from the Chawmanu rain gauge station, while the Kamalpur valley was compared with data from the KVK Dhalai station. The Longtarai Hill separates the two valleys. A good correlation was observed between rainfall and spring discharge. The spring rising limb begins in April/May with pre-monsoon rains, with peak discharge observed during mid-monsoon. Discharge dwindles after the cessation of rainfall, gradually decreasing until the next rainfall event. Precipitation of less than 100mm was observed to have no significant impact on spring discharge. A one-month lag is generally observed between peak rainfall and peak spring discharge in both valleys.

The discharge hydrograph, which extends from a peak to the base of the next rise, represents the recession period during times of no significant precipitation. Analysis of this recession curve helps understand spring aquifer characteristics, separate different flow components, and predict discharge during low-flow conditions, making it integral to sustainable spring water management. Spring discharge data from 2023–2024 were analyzed by fitting the observed curves to Maillet's equation. The initial (Q0) and final (Q1) discharge values at the beginning and end of the recession period differed between 2023 and 2024 for the same springs, indicating rainfall dependency. A drastic reduction in rainfall in 2023 was reflected in lower discharge, whereas higher precipitation in 2024 resulted in increased discharge and higher Q0 and Q1 values. For most springs in Dhalai, the recession coefficient is low, indicating aquifers with low hydraulic conductivity.

It was observed that the dynamic reserve of five springs in Manu Valley is nearly equal to that of 15 springs in Kamalpur Valley, despite higher recharge in Kamalpur. This indicates that the Manu Valley aquifer is more permeable, leading to a higher dynamic reserve but also making its springs more prone to depletion over time.

During the study, 13 Vertical Electrical Sounding (VES) surveys were conducted. These identified approximate groundwater potential zones between 1 and 100 meters deep, highlighting significant opportunities for groundwater development. The VES studies delineated an impervious clay bed beneath pervious to semi-pervious layers, which inhibits downward water flow and forces groundwater to emerge as contact-type springs.

Water quality assessment highlights key concerns and recommendations for sustainable use. suitability for drinking was evaluated against Bureau of Indian Standards (BIS) guidelines, particularly for iron (Fe) and manganese (Mn). While most springs met BIS limits during the monsoon, increased mineralization was observed post- and pre-monsoon due to reduced recharge and longer residence times. Iron and manganese exceeded permissible limits in some samples, necessitating mitigation strategies like oxidation, filtration, or adsorption. Piper plot interpretations reveal a gradual shift in groundwater chemistry from calcium-magnesium-bicarbonate (Ca-Mg-HCO_3) dominance during the monsoon to sodium-enriched compositions pre-monsoon.

Major concerns include land degradation from Jhum cultivation, changes in land use patterns (e.g., road construction), deforestation, forest fires in recharge areas, grazing, and erratic rainfall. The proposed rejuvenation plan includes artificial recharge works like trenches and ponds to capture surface flow and enhance infiltration. It also emphasizes protecting springsheds from anthropogenic interference. Spring sustainability depends on community awareness and active participation in periodic maintenance and monitoring. As government attention to individual springs may be limited, forming and training village committees is essential.

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(NAQUIM 2.0)

Sustainable Springshed Management in Dhalai Dist. of Tripura

1. INTRODUCTION

1.1. GENERAL:

NAQUIM: The Aquifer Mapping and Management programme (NAQUIM) was launched by CGWB in the year 2012 as per the recommendations of the Report of the Steering Committee on Water Resources and Sanitation for Twelfth Five Year Plan (2012-2017), Planning Commission. NAQUIM was taken up with the objectives of delineating aquifers, characterizing aquifers and preparing aquifer management plans. National level mapping of Aquifers on 1:50,000 scale was considered sufficient for planning requirements up to block level. Some of the important uses of Aquifer mapping at 1:50,000 scale includes:

i. Identification of suitable areas for ground water based supply to large urban agglomerations,
ii. Determine sustainability of groundwater development,
iii. Identification of aquifers capable of providing water supply during protracted drought periods,
iv. Prioritization of aquifers for managed aquifer recharge,
v. Identification of aquifers and determination of their suitability for various purposes in regions where new urban centres or industrial hubs are likely to come up in future,
vi. Planning of integrated ground water recharge schemes,
vii. Issuing advisories to the state agencies on repercussions of continued development of groundwater in select areas,
viii. Recommendations to state agencies in respect of areas that have prospects for ground water development etc.

NAQUIM 2.0: Though the NAQUIM outputs have been useful for sustainable ground water management in numerous ways as enumerated above, large scale implementation of its recommendations at ground level by the user agencies has been lacking. As per the feedback received from the agencies using the NAQUIM outputs, major limitations of the ongoing studies include i) non-availability of printed maps at usable scales and ii) lack of site specific recommendations for implementation at Panchayat or village level.

Keeping the above limitations in mind and considering the future requirements, broad objectives of NAQUIM 2.0 studies will be

i. Providing information in higher granularity with a focus on increasing density of dynamic data like ground water level, ground water quality etc.
ii. Providing issue based scientific inputs for ground water management upto Panchayat level,
iii. Providing printed maps to the users and
iv. Putting in place a strategy to ensure implementation of the recommended strategies. Involving state agencies in the studies for a sense of ownership.

The studies under NAQUIM 2.0 are proposed as issue specific and will be undertaken in prioritized focus areas. Broadly 11 Priority areas are identified based on ground water related issues as given below:

1: Water Stressed Areas; **2**: Urban Agglomerate; **3**: Coastal Areas; **4**: Industrial Clusters and Mining Areas; **5**: Areas with springs as the principal source; **6**: Areas with Deeper Aquifers; **7**: Ground Water Contamination; **8**: Auto-flow zones; **9**: Canal Command Areas, **10**: Areas with poor ground water quality, **11**: Other specific Issues.

The Present Study: The present study has been assigned w.r.t **priority area 5: Areas with springs as the principal source,** for the Dhalai District of Tripura. The deliverables under this head in brief are numerated as below along with the achivements:

a) Aquifer Dispositions: The details have been compiled and tabulated.

b) Aquifer-wise ground water Levels: Has been compiled and tabulated.

c) Delineation of Recharge Areas: Springshed Mapping is being undertaken. Based on the initiatives taken by CGWB, SUO Agartala Office, some of the NGO at present are carrying out the activity with the data inventoried by CGWB.

d) **Estimation/Refinement of parameters used for resource assessment:** Not Applicable in case of Spring Studies. A Spring inventory form was devised in-house for the data collection. The format devised was prior to NIH Workshop and is better in usability. NIH Spring Working group has now incorporated some of our parameters like: owner of Spring-Shed, Nearby Industrial Activity, Colour of Water, Smell in Water, Coloration/stains in the surrounding, Cleanliness of the surrounding, Dimensions of the Present Spring Chamber etc.

e) **Assessment of ground water resources:** The calculation has been based on the recent GWRE, 2023-24 and the same has been incorporated.

f) **Location, Discharge and water quality of the springs, vulnerability of the springs:** A Total of 40 Number of Springs were Inventoried, of them 20 Number of Springs were monitored monthly (Barring few Rainy months due to its inaccessibility). The Vulnerability assessment of the spring has been carried out and enumerated in the following chapters. Through visual & field interpretation, the spring types were identified as Contact Springs and Depression springs with few as Fracture springs. Based on discharge, the springs were differentiated based on Meinzer, 1923, mostly falling into 7th and 8th order with very low discharge of the springs. 21 Number of Vertical Electrical Sounding stretching from 50 mtrs to 1 km, with few transverse section were carried-out and their results matched with the surrounding Lithology and the mouth of the springs. A few more VES Studies were carried out in the Southern Part of the districts, although away from the springs. There has been a clear-cut relationship between change is type of lithology inferred from Geophysical data with the discharge point of the springs.

g) **Demarcation of the springshed:** Some of the Springshed in the districts have been demarcated and has been detailed in the following chapters.

h) **Ground Water Quality:** Post Monsoon Water Sample collection (Nov, 2023) and Pre-monsoon (March, 2024) were collected from these spring and were analysed. The data are presented in the Annexures. The Isotope samples from few of the springs were collected and have been sent for analysis (result still awaited)

i) **Identification of potential aquifers for drinking water supply:** The Aquifers have been identified for drinking water supply. Some of these are under consideration for innovative water supply schemes of Government of Tripura. (ex; Chichincherra)

j) **A plan for drinking water source sustainability:** Springshed management is being promoted through NGOs and other bodies working in the area.

k) **Identification of potential aquifers for Irrigation:** Not Applicable.

l) **Recommendations for springshed management:** The Springshed area were demarcated for some of the Springs. The details were shared with the State Government Authorities. Based on the Inputs, some of the NGO's like Tata Trust, CML have been working on the Springs inventoried by CGWB for Springshed Development. There has been rapid decline in discharge in majority of the springs, with some springs almost going dry in summer seasons. These are mostly attributed to anthropogenic activity, like Road Construction (where in the springs mouths are plugged or diverted to stop soil erosion), Change in Plantation/cultivation (Forest converted to Rubber & Betel Nut cultivation, Original Thick Forest with Shrubs: More water retention, more Infiltration, Less soil erosion, hence recharging Springs, Channelized Cultivation like Rubber & Betel nuts: Better Drainage, absolutely no Water Retention, no infiltration, Soil Erosion, No Recharge to the springs.

m) **Recommendations for spring water harvesting:** There is no scope of Spring Water Harvesting, as the discharges of the Springs are very very Low, mostly falling into 7^{th} and 8^{th} order of Meinzer 1923 classification.

1.2. SPRING INVENTORY IN THE NORTH TRIPURA DIST (JAMPUI HILLS) OF TRIPURA:

The water resources of Tripura state is being looked after by the PWD (WR), Government of Tripura, whereas the water supply through various schemes is being looked after by the PWD (DWS). Till, 2020-21, there had been no inventory carried out by the State Government for the counting as well as existence of Springs across Tripura.

In the **AAP 2021-22**, the inventory of the springs was carried out in the North District of Tripura, in the Jampui Hills area. In total, 40 springs were inventoried and 35 springs were monitored for Water Quality parameters and discharge.

The report has been placed at CGWB's Website:
https://cgwb.gov.in/cgwbpnm/public/uploads/documents/1744184039231617652file.pdf

Some of the salient feature of the study is listed below:

- Springs are the major source of fresh water specially in the mountainous area of Tripura.
- A total of 35 different springs in the Jampui Hills were inventoried, and data along with Water Sample collected.
- On the basis of geological structure of the formation, three types of springs are identified viz, Contact Spring (6 nos), Depression Spring (12 nos) and Fracture Spring (17 nos).
- Discharge ranges from 0.33 lpm to 1200 lpm.
- On the basis of discharge, the springs are classified as per Meinzer classification (Falls in the order of 4th to 8th)
- Suitable for drinking and domestic use.
- Some of the springs have a small catchment area and low thickness of feeding aquifers etc., hence are highly vulnerable to low discharge.
- There is a need to restore and preserve the spring as it is the source of fresh water to the local community.

Phuldungsei 1 spring (pre-monsoon). (Fracture spring)

Phuldungsei 1 spring (post-monsoon) with Turbid Water

Tlangsang 3 spring (Fracture spring)

Tlangsang 2 Spring. (Contact spring)

Tanky para 1 (Depression spring)

Tlangsang 5 Spring. (Depression spring)

Figure 1-1: Springs of North Jampui Hills, North Tripura District

Based on the Spring study, the Government of Tripura implemented Innovative water supply schemes through tapping Spring as sources for Water supply in North Tripura district of Tripura. One of the best example is The "Innovative water supply scheme at Phuldungsei" a project under the Jampui Hill RD Block area in North Tripura, aiming to improve water supply in the region. The supply is completely based on tapping the Spring as the source for Water supply.

Figure 1-2: Innovative water supply scheme at Phuldungsei

With the overwhelming response from the State Government of Tripura, in the Financial Year, 2023-24 (AAP 2023-24), this office has been assigned to undertake the Spring Study in the Dhalai Dist. of Tripura. However, owing to the staff and other resources constraints, the duration was extended for the FY 2024-25 (AAP 2024-25).

1.3. NEED FOR SPRING INVENTORY IN TRIPURA:

The following pictures presented are one of the general sights across Tripura.

Figure 1-3: Due to water scarcity in the area, people waiting with utensils for Water Tanker for supply

1.4. SPRINGS IN THE STUDY AREA (PREVIOUS STUDIES & EXISTING DATA):

Springs have been reported in the Dhalai District by several earlier workers in the Ambassa and other nearby areas. Some of the springs have been clearly marked in the Toposheet of Survey of India.

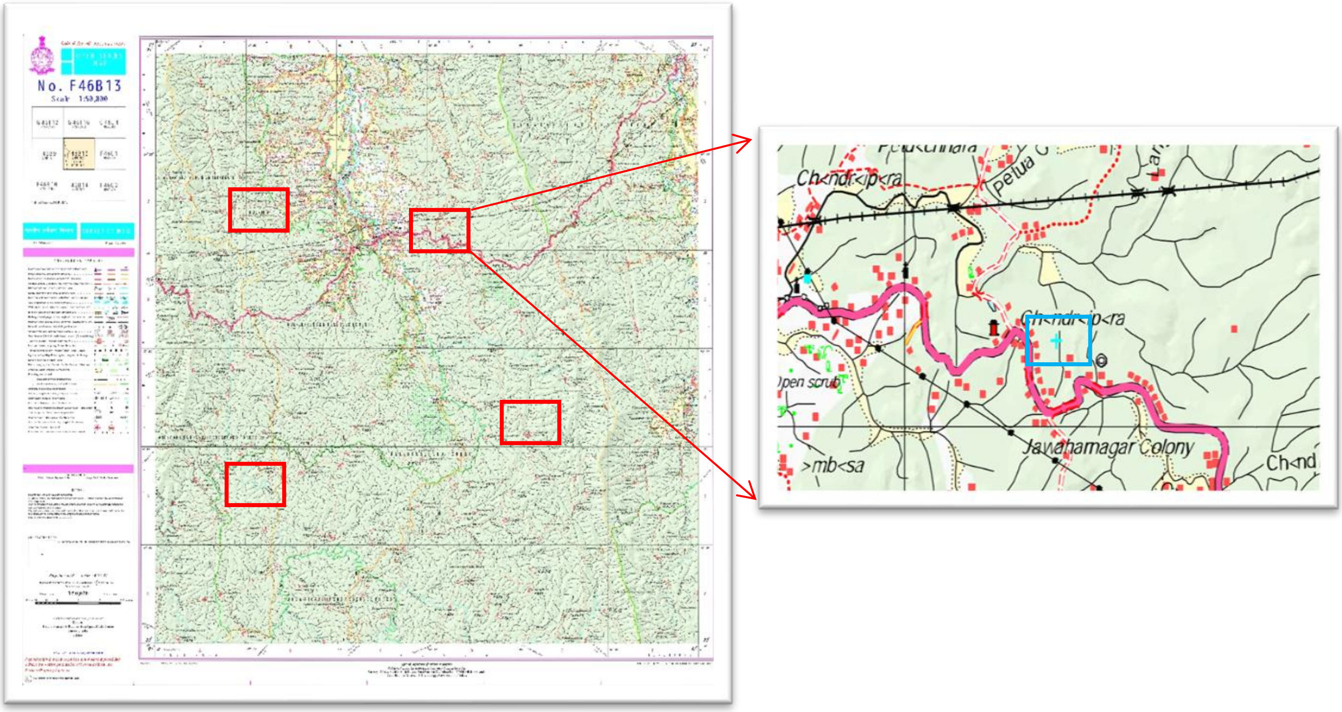


Figure 1-4: Marking of Springs in the toposheets of Survey of India

Some of the location as mentioned in the toposheets are:

Table 1:1: Springs locations as per toposheet:

Sl No.	Toposheet No	Quadrant	State	District	Name of Nearby Village
1	79 M/13	1A	Tripura	Dhalai	Hazabari Spring
2	79 M/13	1B	Tripura	Dhalai	Chandraipara
3	79 M/13	3A	Tripura	Dhalai	Biswamanibari (Hot Spring)
4	79 M/13	3C	Tripura	Dhalai	SatrughanBari
5	79 M/13	3C	Tripura	Dhalai	Tejendrabari
6	79 M/13	3C	Tripura	Dhalai	Tamaraibari

Apart from the above, as per a recent list received from the Member (East), few more springs have been demarcated by Survey of India and some other organisation in this area.

Table 1:2: Location of Springs as shared by Survey of India, w.r.t the mail from Member East, CGWB on 27th April, 2023

Sl No.	FID	Object ID	Latitude	Longitude	Source of Data	Village_Na
1	1237	1238	23.75333	92.095	PHE Mizoram	CC Reserved Forest
2	1239	1240	23.6745	92.03583	PHE Mizoram	CC Reserved Forest

3	1244	1245	23.755	92.09	PHE Mizoram	CC Reserved Forest
4	1248	1249	23.67503	92.045	PHE Mizoram	CC Reserved Forest
5	5257	5259	23.79105	91.95446	SOI	Chakmapara
6	5258	5260	23.81571	91.94441	SOI	Baluchhara
7	5259	5261	23.82028	91.94365	SOI	Baluchhara
8	5262	5264	23.82727	91.95578	SOI	Dakshin Longtarai
9	5270	5272	23.92182	91.88699	SOI	Ambasa

Some zones were identified adjacent to the neighbouring Dist. and were considered to mark the spring lines, and based on the same, springs were identified in the study area.

1.5. DEVICING A FORMAT FOR DATA COLLECTION & COMPILATION

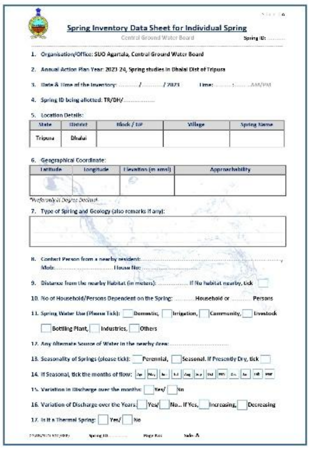
Although several formats were available, but were all designed for only One Time Spring Inventory (like Niti Aayog, ICMOD, NIH etc). Hence there was a need for a format for future Springshed rejuvenation work along with long term monitoring of these Springs. Some of the reports and booklet already available are projected below.

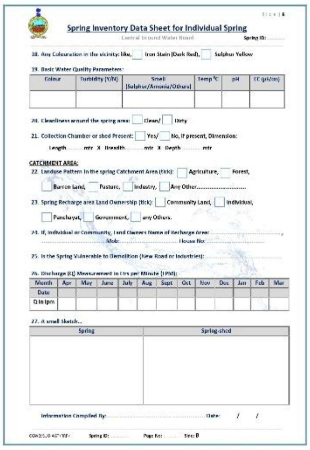
Figure 1-5: Cover page of some of the published literatures on Springs

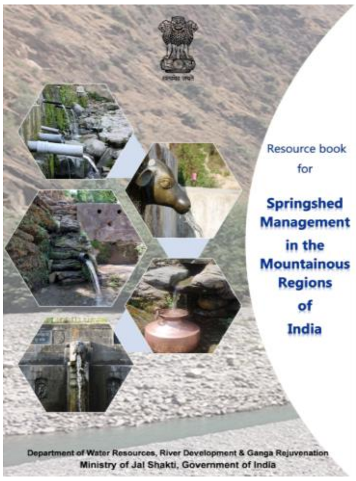
This format was devised Prior to the NIH workshop with unique parameters like (i) Owner of the Springshed, (ii) Any Industrial activities in the vicinity, (iii) Colour of the water, (iv) Smell of the water, (v) Colouration of Stains in the surrounding, (vi) General Hygiene and cleanliness of the surrounding (vii) No of dependent of the Spring, (viii) availability of alternative source of drinking water, (ix) Is the spring vulnerable to demolition (Road and Industries) and (x) Availability and Dimension of the Spring Chamber.

The usability of this devised format for Data entry was easier and much better then the previous ones because, (i) most of the entry were tick mark type, (ii) can be used by the survey team as well as by the supervising team and (iii) One sheet was enough to capture all the survey details and can be referred leteron.

Later on these parameters were included in the Resource Book for Springshed Management in the Mountainous Regions of India, in the year 2024 (QR Code to download the resource book is given below).


Spring Inventory Data Sheet for Individual Spring
Central Ground Water Board


Spring Inventory Data Sheet for Individual Spring
Central Ground Water Board



The detailed legible sheets 1 & 2 are given in the Annexure 11.15 for use.

Figure 1-6: Spring Manual and Spring inventory form

1.6. SPRINGS & THEIR CLASSIFICATION:

A spring is a natural exit point at which groundwater emerges out of the aquifer and flows onto the top of the Earth's crust (pedosphere) to become surface water. Springs have long been important for humans as a source of fresh water, especially in hilly areas. Springs are driven out onto the surface by various natural forces, such as gravity and hydrostatic pressure. A spring produced by the emergence of geothermally heated groundwater is known as a hot spring. Springs have aided in the advancement of human civilization.

Spring describe as concentrated discharge of ground water appearing on the surface as flowing water (Todd, 1995, p-48). Seepage areas are which indicate a slower movement of ground water to the ground surface. Spring are fed by aquifers system i.e. the types of rock present in that area, which stores and transmits water to those springs. Rocks of various type show different properties which are characteristics of their process of formation. All these properties influences behaviour of spring. Accordingly, springs have been classified into various types depending upon various criterion like rock structure, discharge, temperature, and variability. Bryan (Bryan, 1919) divided all springs into (1) those resulting from gravitational forces and (2) those resulting from non-gravitational forces. Under the former are included volcanic springs (associated with volcanic rocks) and fissure springs (resulting from extending to greater depth in earth’s crust).

1.6.1. Classification based on Nature of Hydraulic Head:

Gravity Spring: This type of spring emerges where water table cuts the surface under unconfined condition. They are also called descending spring.

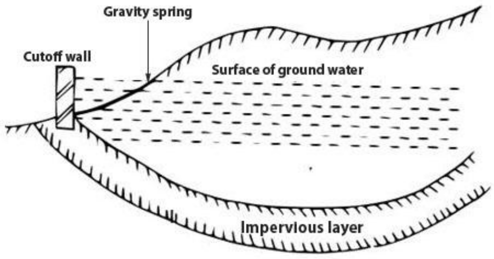


Figure 1-7: Gravity Springs

Artesian Spring: This type of spring emerges under pressure surface under confined condition of the aquifer. They are also called ascending or rising spring.

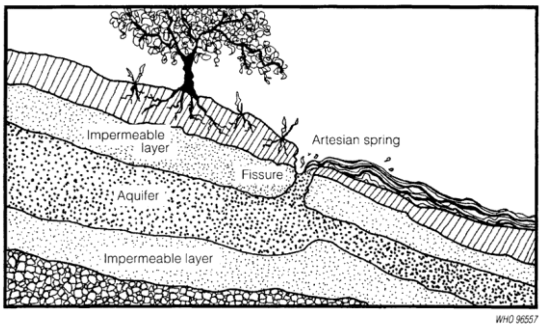


Figure 1-8: Artesian Spring

1.6.2. Classification based on Geology:

(a) Depression Spring: They are formed when the water table intersects the topography. In this type of spring the discharge may vary depending upon the position of water table of that area. As the Springs are formed because of earth's gravitational pull they are named depression or gravity springs. These are usually found along the hillside and cliffs.

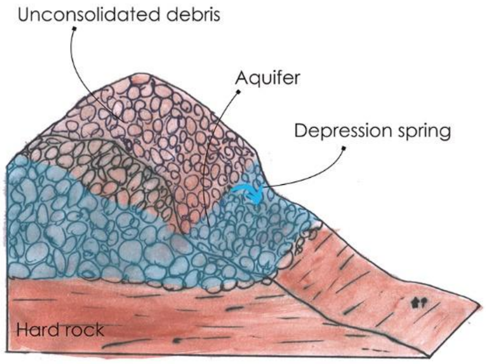


Figure 1-9: Graphical representation of a Depression spring

(b) Contact Spring: This kind of springs formed at the contact zone where relatively permeable rock formation overlies rock formation of low permeability. As a result, water comes out from such contact as flow. They are known as contact spring.

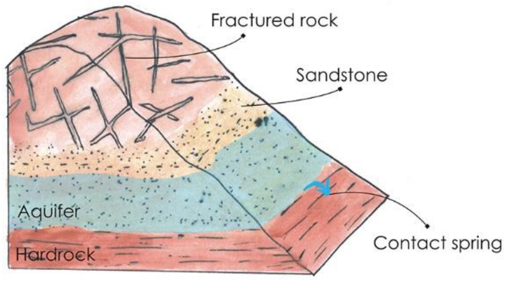


Figure 1-10: Graphical representation of a Contact spring

(c) Fracture Spring: Springs of this type occur due to presence of permeable fracture zones in rocks of less permeability. Groundwater moves mainly through porous fracture zones that constitute the porosity and permeability of aquifers. Springs are formed where these fractures intersect the ground surface.

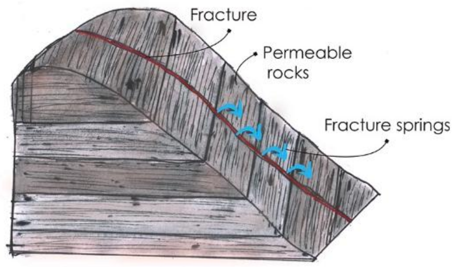


Figure 1-11: Graphical representation of a Fracture spring

(d) Fault Spring: Faulting may also sometimes give rise to conditions in which groundwater (at depth) under hydrostatic pressure (such as in confined aquifers) can move up along such fault openings to form a spring.

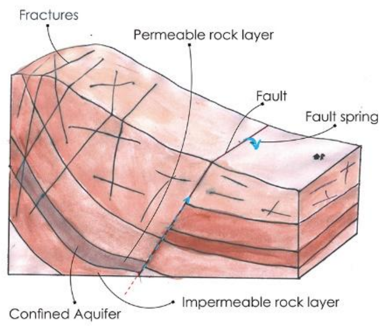


Figure 1-12: Graphical representation of a Fault spring

(e) Karst Spring: The term 'Karst' is derived from a Slavic word that means barren, stony ground. It is also the name of a region in Slovenia near the border with Italy that is well known for its sinkholes and springs. Geologists have adopted karst as the term for all such terrain. Cavities are formed in carbonates rocks (limestones, dolomites, etc.) due to dissolution of rock material by chemical reaction. Water moves through these cavities and openings to form a spring or a system of springs.

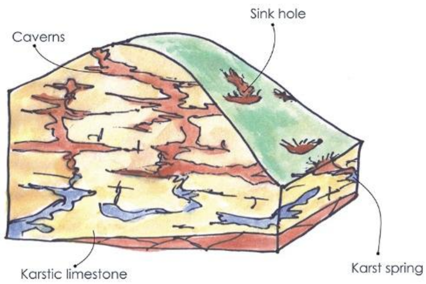


Figure 1-13: Graphical representation of a Karst spring

1.6.3. Classification based on Discharge of the Spring:

The Meinzer Magnitude of Spring Discharge is a classification (Meinzer,1923) system developed by Oscar E. Meinzer to categorize springs based on their average discharge (flow rate)**,** typically measured in gallons per minute (gpm) or liters per second (L/s)**.** The spring discharge depends on the area contributing to the recharge of the aquifer and the rate of recharge. Mostly spring discharge fluctuate in the rate of discharge in response to the periods ranging from minutes to years, depending on geologic and hydrologic conditions.

Table 1:3: Meinzer Classification of Springs according to Discharge

Meinzer's Classification of Springs According to Discharge

Magnitude	SI Units	British Engineering Units
1st	>2.83 m^3/sec	> 100 ft^3/sec
2nd	0.283 to 2.83	10 to 100
3rd	28.3 to 283 l/sec	1 to 10
4th	6.31 to 28.3	100 gal/min to 1 ft^3/sec
5th	0.631 to 6.31	10 to 100
6th	63.1 to 631 ml/sec	1 to 10
7th	7.9 to 63.1	1 pint/min to 1 gal/min
8th	< 7.9 ml/sec	< l pint/min

Source: Meinzer, 1923.

2. NAQUIM 2.0 STUDY: SPRINGS IN DHALAI DIST., TRIPURA

2.1. ABOUT THE STUDY AREA:

Dhalai District of Tripura was created in the year of 1995 by bifurcating North Tripura District and including part of Amarpur Sub-Division of the South Tripura District. It was created keeping in view the administrative exigency of providing development & good governance to the largely Tribal & inaccessible areas. The District is named after Dhalai river which originates in the District.

The Dhalai district of Tripura confined within North Latitudes **23⁰ 24′ 38″** and **24⁰ 15′** and East Longitudes of **91⁰ 45′** and **92⁰ 15′**. The area is falling mainly and partly in Survey of India Toposheets bearing nos. 78P/16, 79M/13, 79M/14, 79M/15, 83D/4, 84A/1, 84A/2 and is bounded by international boundary of Bangladesh in North and South, by North Tripura District in the East and by Khowai and Gomati in the west. Under the NAQUIM 2.0, it was proposed to undertake the Spring Inventory of about 900 sq.km. of Hilly part out of the entire Dhalai District of Tripura covering 2312.29 sq km.

Socio-economically it is one of the most backward district of the state. In 2006 the Ministry of Panchayati Raj named Dhalai one of the country's 250 most backward districts (out of a total of 640). It is the only District of Tripura which receives grants from the Union Government under the Backward Regions Grant Fund (BRGF). An overwhelming 76% of the workers are dependent on agriculture for their livelihood. Practice of Jhum cultivation (shifting cultivation) still continues in many parts of the District by the tribal residing in the deeply forested hills. The fertile Valleys are mostly occupied by the non-tribal, mostly Bengalis and are the primary centres of economic activity in the District. 25% of the households in the District are classified as Below Poverty Line (BPL).

Table 2:1: List of Sub-Division, Blocks and Tehsils in Dhalai District of Tripura

Sl. No.	Name of the Sub-division	Headquarters	Name of Blocks	Name of Tehsils
1	AMBASSA	Ambassa	1. Ambassa 2. Ganganagar	1. Ambassa 2. Dalubari 3. Nalichara 4. Shikaribari 5. Ganganagar
2	KAMALPUR	Kamalpur	1. Salema 2. Durgachowmani	1. Kamalpur 2. Barasurma 3. Mahabir 4. Manikbhander 5. Mayachari 6. Baralutma 7. Halhali 8. Salema 9. Kachuchara
3	GANDACHERRA	Gandacherra	1. Dumburnagar 2. Raishyabari	1. Gandachara 2. Jagbandhupara

				3. Raishyabari 4. Hathimatha
4	LONGTHARAI VALLEY	Chailengta	1. Manu 2. Chawmanu	1. Manu 2. Chailengta 3. Karamchara 4. Chawmanu 5. Manikpur 6. Gobindabari
Total	**Dhalai District**	**4 Sub Divisions**	**8 Nos. Blocks**	**24 Tehsils**

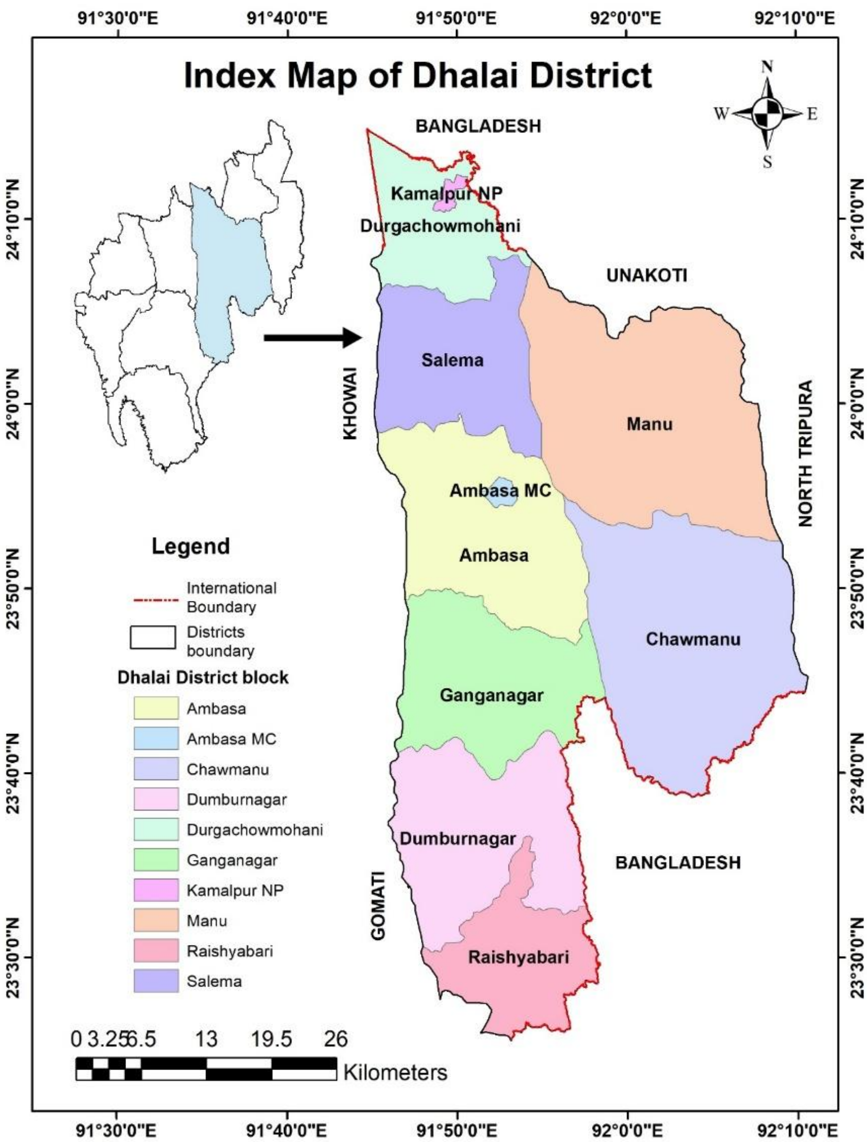


Figure 2-1: The Map of the study area.

2.2. CLIMATE AND RAINFALL:

The climate of the state is tropical, highly humid and is characterized by moderate temperature with three prominent seasons - summer, monsoon and winter, where summer spans from March to May followed by southwest monsoon lasting till September. Winter sets in in November and lasts till the end of February. Summer season starts from March and lasts upto May and is followed by Southwest monsoon lasting till September. Generally, the maximum summer temperature ranges from 35^0C to 40^0C and average minimum temperature in winter nights is recorded at 6^0C.

Humidity generally remains high throughout the year. Generally, it is high in July and low in March. Relative humidity in a year generally varies from 70% to 85%. In summer, relative humidity varies from 60 to 75% in the morning and from 50 to 60% in the evening. In rainy season, relative humidity remains over 85% in the morning and from 70 to 80% in the evening. Relative humidity recorded at Agartala during a long period in the recent past is 89% to 63% in the morning and 80% to 50% in the evening.

The state receives rainfall from Southwest Monsoon. The average annual rainfall over the state is 1911 mm. The intensity of rainfall increases from SW to NE in the state. In Dhalai dist of Tripura, normal monsoon rainfall is 1387 mm and normal annual rainfall is 2530 mm. The detailed rainfall data have been compiled in the **Annexures (11.5)**.

2.3. STRUCTURE:

Tectonically, the area comprises a sub-parallel, arcuate, elongated, doubly plunging folds arranged en-echelon pattern and trending in an average north-south direction with slight convexity to the west (Kher and Ganju, 1984). The folds are characterized by tight and narrow, box like anticlines alternating with broad flat synclines. The anticlines forming ridges are symmetrical and traversed, in most cases, by north-south longitudinal reverse faults. The microscopic folds are varied in style. They are preserved mostly in the thinly laminated multilayer of silt-shale alternations of both Bhuban and Bokabil Formations. Two types are common sharp crested and disharmonic. Parallel (concentric) folds, overturned, recumbent and box folds are confined to the eastern sector.

2.4. PHYSIOGRAPHY:

Physiographically, the area can be divided into two parts, viz., Anticlinal Hill Ranges and Synclinal flat bottomed valleys. The important hill ranges are Atharamura, Langtarai and Sakhantlang. These hill ranges are tightly folded and trending almost N - S. The height of the hill ranges gradually decreases towards west. The hills are covered with thick forest cover. More than 70% area is hilly and forest covered. The terrain is mostly undulating & hilly with small water streams (chharas), rivers and fertile valleys intervening. Major rivers originating from Dhalai are Dhalai, Khowai, Gomati & Manu. Major hills are Atharamura, Longtharai, Kalajhari & part of Sakhan.

The broad synclinal valleys occurring in the district are;

(1) Kamalpur valley
(2) Gandacherra valley and
(3) Manu valley

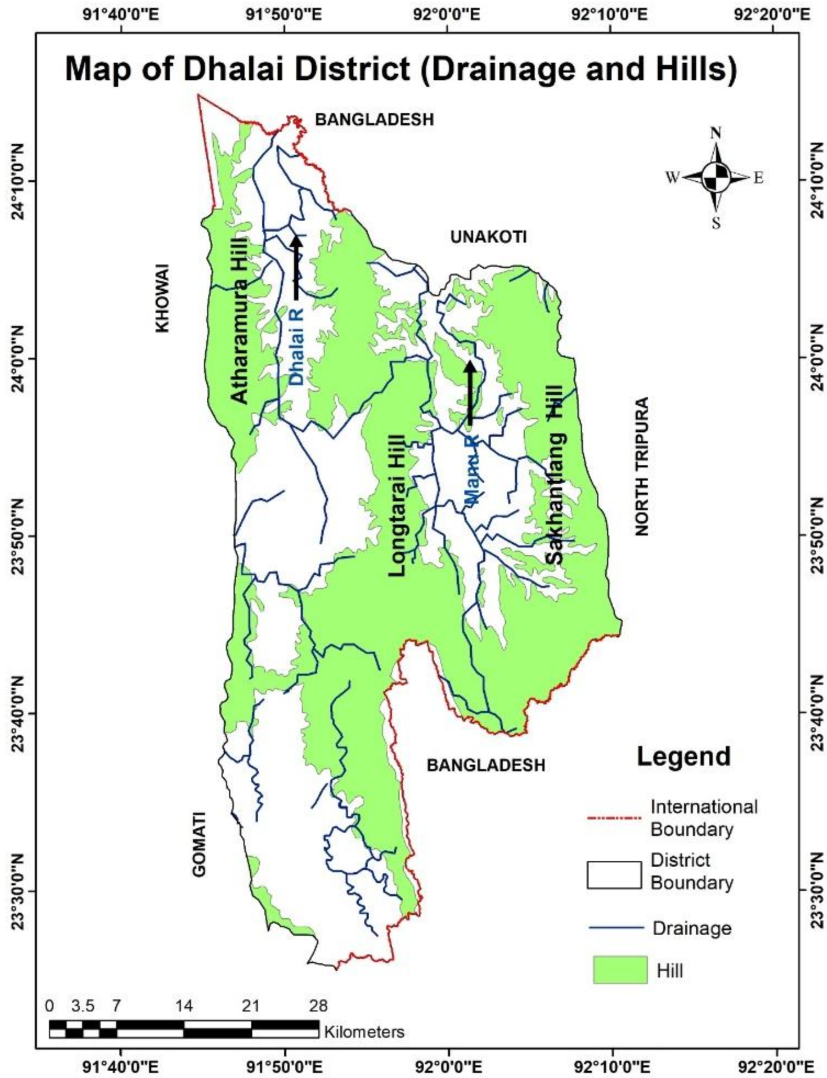


Figure 2-2: The Drainage and Hill Map of Dhalai dist. of Tripura

2.5. GEOLOGY:

Geologically, the study area is occupied by Quaternary & Upper Tertiary groups of rocks. ***Surma Group:*** The Surma Group is represented by Upper Bhuban and Bokabil Formations. The rocks of Bhuban Formation, constituting compact sandstones and shales, which are exposed in the core of the anticlines of the district, viz., SakhanTlang, Jampui hills and Longtarai etc. ***Tipam Group:*** The Tipam Formations are conformable and transitional to the underlying Bokabil Formation. These Formations are arenaceous in nature and comprised of fine to medium grained, yellow to light buff and brownish yellow colour, friable sandstones, and occur along the outer flanks of the anticlinal hill ranges with moderate dip to near horizontal disposition. ***Dupitila Group:*** The Dupitila sediments consisting of earthy brown to buff sandy clay, mottled clay, clayey sandstone and coarse to gritty ferruginous sandstone unconformably overlie the Tipam Formation, and are well developed in central portion of the synclinal valleys. ***Recent Group:*** Recent alluvium occurs along the streams and the flood plains of major rivers. It consists of coarse sand, sandy clay, silt, silty clay and clay etc.

2.6. HYDROGEOLOGY:

Sub-surface geology has been interpreted from boreholes drilled by CGWB and various State Government Agencies. Granular zones encountered down to a depth of 300 m belong to semi-consolidatedTipam and Dupitila groups and constitute medium to coarse grained, sub-rounded quartz, feldspathic material, whose occurrence and thickness vary laterally as well as vertically.

The Gandacherra valley has not been explored much by CGWB or the State Govt, as the prospect of availability is Ground Water is less.

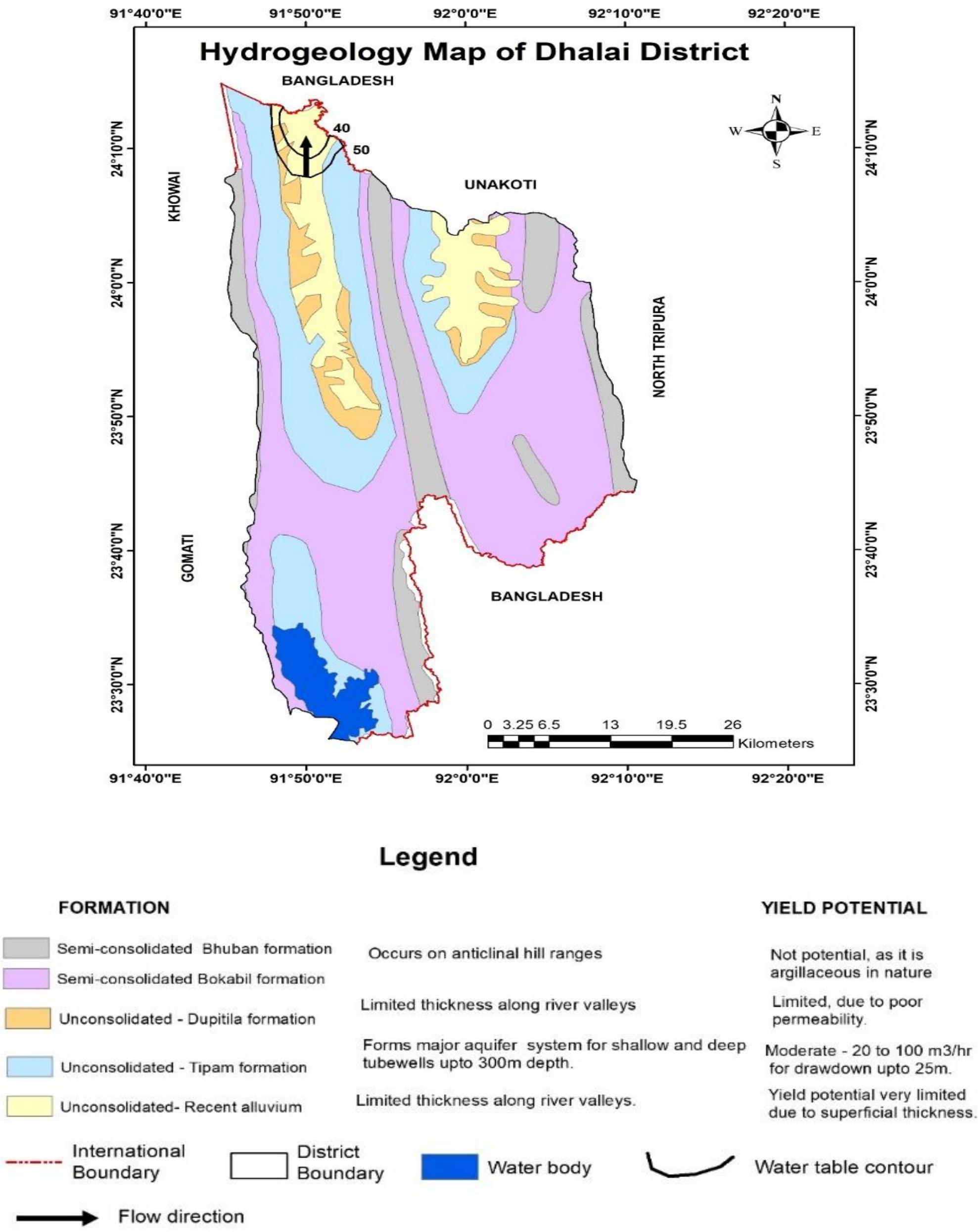


Figure 2-3: The Hydrogeological Map of Dhalai dist. of Tripura

2.6.1. Kamalpur valley:

Kamalpur valley containing Salema and Durga Chowmuhani blocks is largely dominated by shaley horizons except in the central part of the valley at Bhatkhowri where three distinct deeper sandstone horizons of significant thickness can be seen. These granular horizons appear to have been displaced due to subsurface faults towards north. The sub-surface configurations of different granular zones in this valley have been shown in a panel diagrams. Three to four numbers of thin granular zones occur within 250 m bgl.

In Ambassa area (Figure 2-4), which is the southern extension of Kamalpur valley, the first shallow granular zone is encountered at 21 m bgl and its thickness is 8 – 10 m and the second granular zone occurring below 50 m bgl. In Bhatkhowri area total 4 nos. of aquifers are available within 300 m bgl. The granular zones are found within the depth ranges 15 – 75 m bgl, 100 – 120 m bgl, 180 – 270 m bgl and also below 285 m bgl.

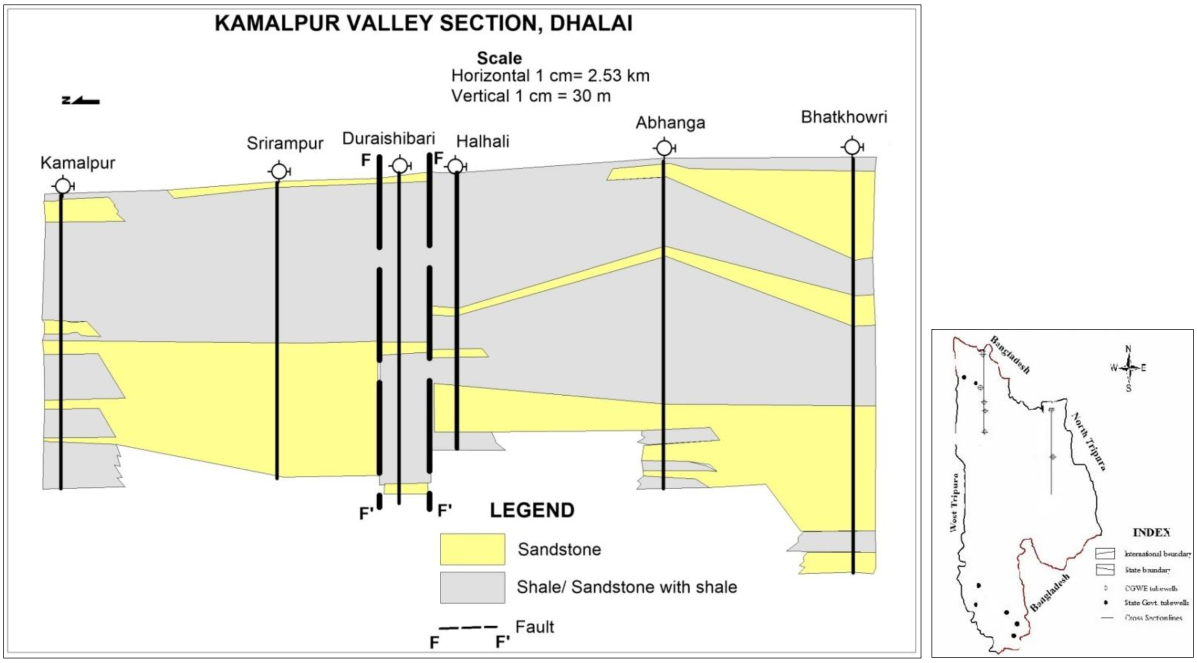


Figure 2-4: Co-relation of Sub-surface Formations in Kamalpur valley of Dhalai District

2.6.2. Manu valley:

The Manu and Chawmanu block area is a part of southern extension of Kailashahar valley. The panel diagram for Manu valley (Figure 2-5) shows the presence of fairly good thickness of fine to medium grained sandstone horizon in the northern part of the valley, covering Karamchera (Manu) area. However, in the fringe area of Langtarai and SakhanTlang hill ranges, clay/shale predominate in the top horizon. Possibly this phenomenon is due to lithofacies change. But in the south while the thickness of granular zone within the first 120 m depths gets reduced due to appearance of tongues of clay/shale horizon the entire thickness of sandstone appears to have been displaced by clay/shale at Chawmanu. This may happen due to fault or lithofacies change. Below the first 100-120 m thick granular horizons observed in the central part of the valley, the other granular horizons at depth are of minor nature and thickness and are intercalated by clay/shale horizons. Another significant granular horizon occurs at a depth below 200 m with almost uniform thickness of 25 to 40 m. These granular horizons form productive aquifers in this valley.

In Manu block, between Manu and Karamcherra, 4 to 5 granular zones are available. The first zone is quite thick and is occurring between 20 – 135 m bgl. Other granular zones are occurring in the depth ranges of 145 – 155 m bgl, 160 – 170 m bgl, 190 – 210 m bgl and 210 – 240 m bgl. Exploratory wells drilled by CGWB at Chawmanu shows the area is dominated by shaley horizons within 300 m bgl. Two good granular zones are occurring in the depth ranges of 120 – 165 m bgl & 210 – 250 m bgl. Apart from this a few very thin granular zones also occur in the depth ranges of 170 – 200 m bgl & 260 – 300 m bgl.

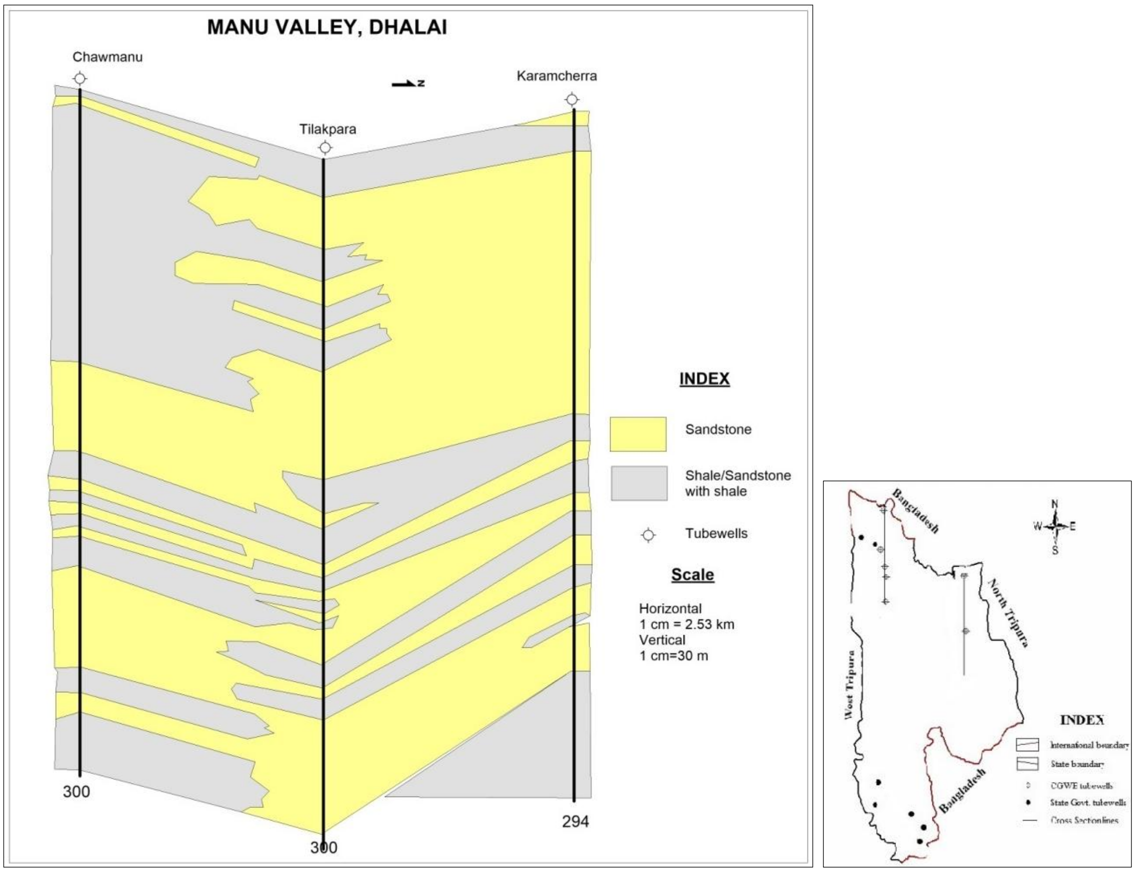


Figure 2-5: Sub-Surface Formations and Aquifer disposition in Manu valley, Dhalai District

2.7. GROUND WATER MONITORING:

At present, there are about 22 (both Deep and Shallow) GW Monitoring wells in the district. Out of the 22 NHNS Station, 14 number of wells have data consistency and the remaining of the wells are either New of replaced over the time. There are No monitoring station located in Gandacherra valleys due to inaccessible forested area, the Damboor Lake and non-availability of monitoring wells. The location of these monitoring wells are given in the following Map.

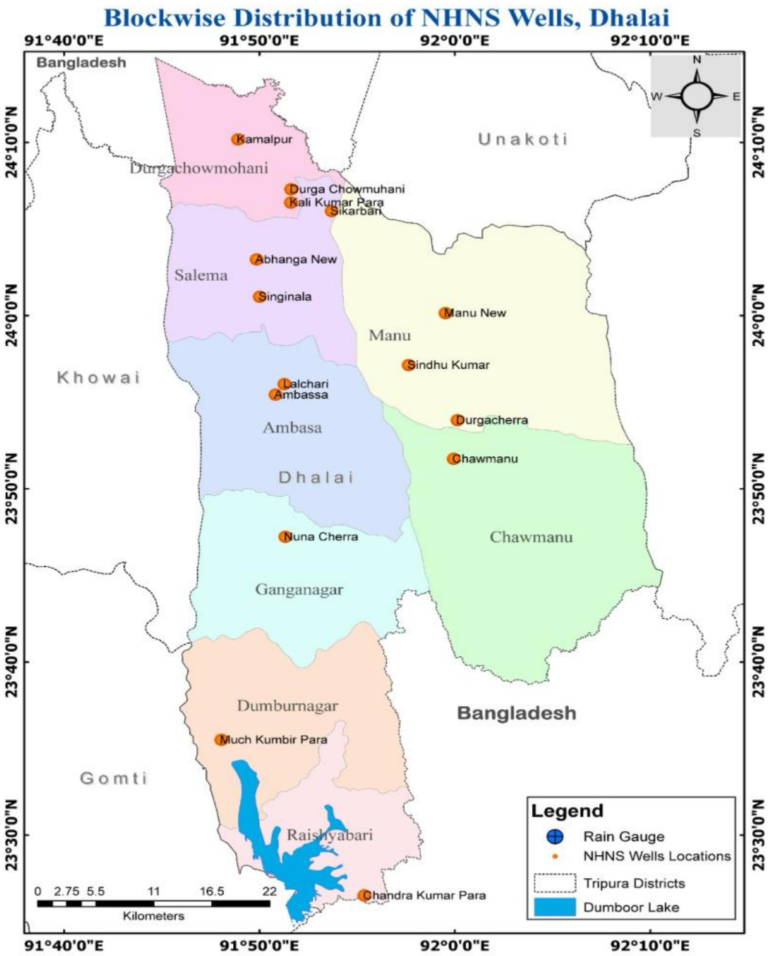
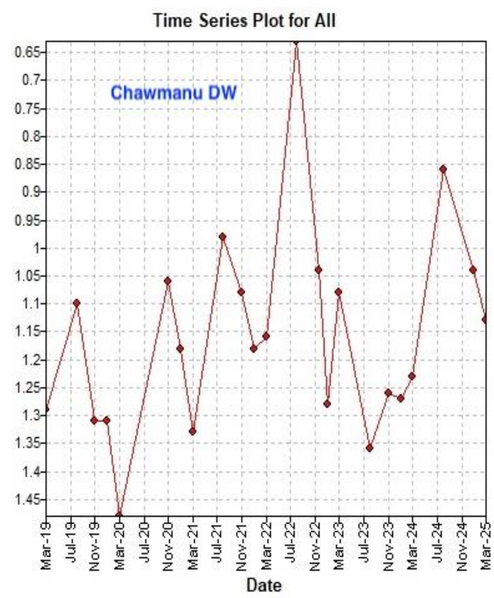


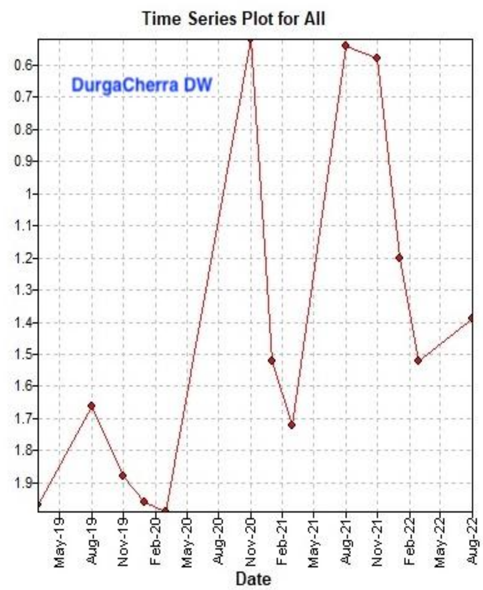
Figure 2-6: Block wise NHNS well distribution in Dhalai District of Tripura

Some of the well Hydrographs are represented below:

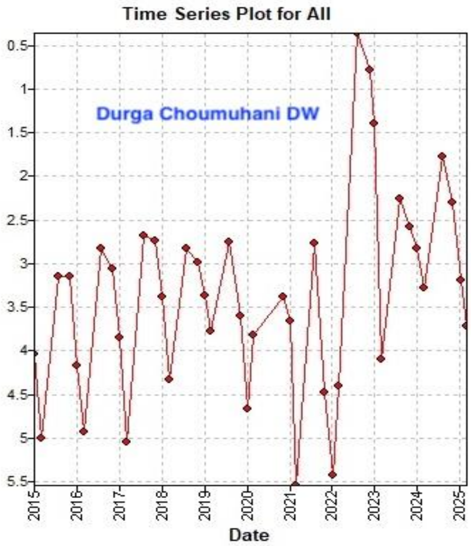
i.



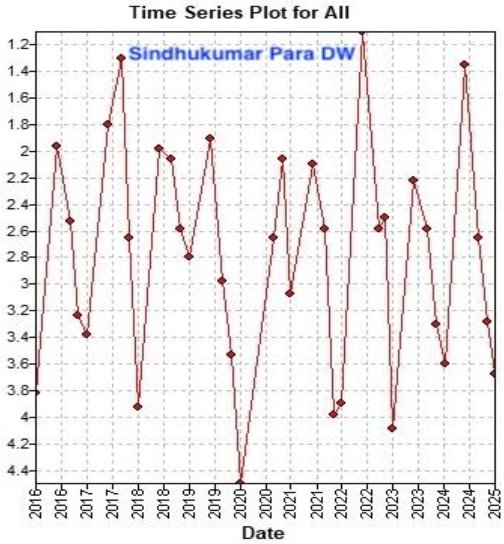
ii.



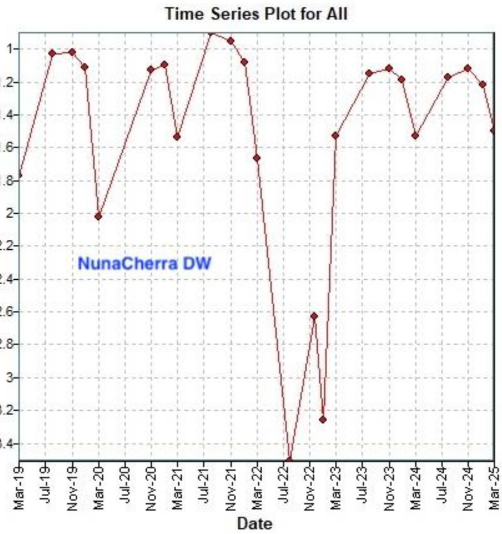
iii.



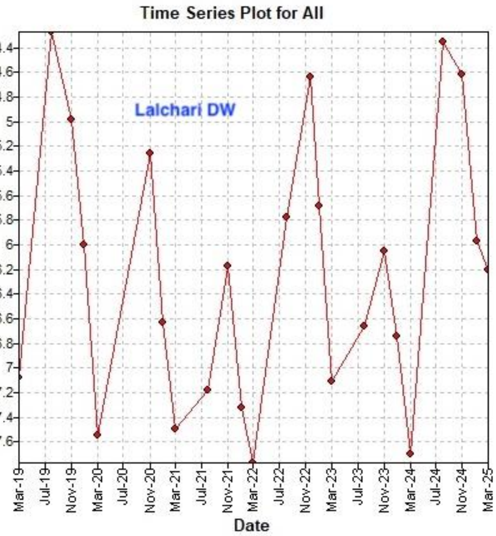
iv.



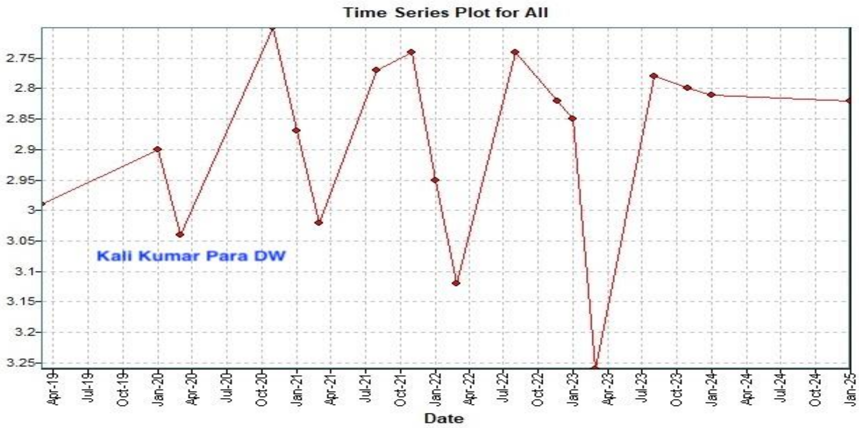
v.



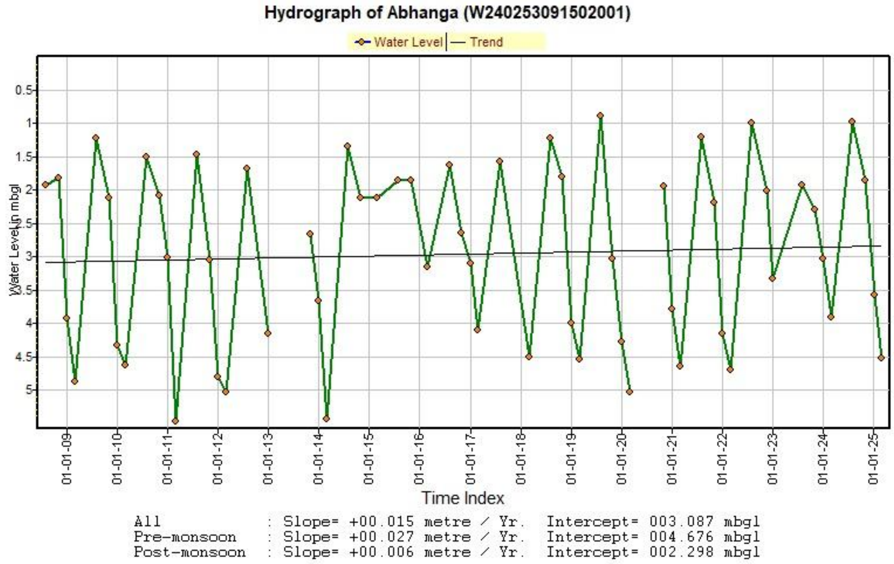
vi.



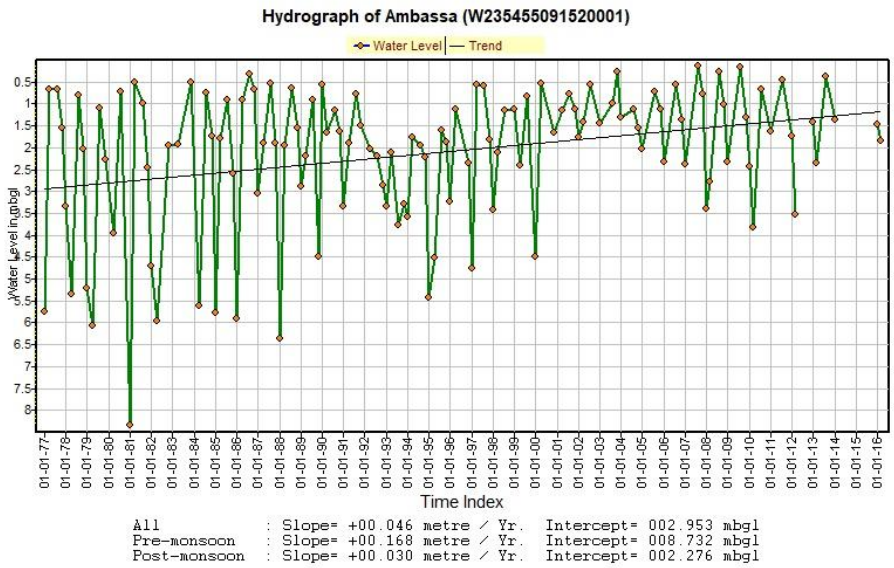
vii.



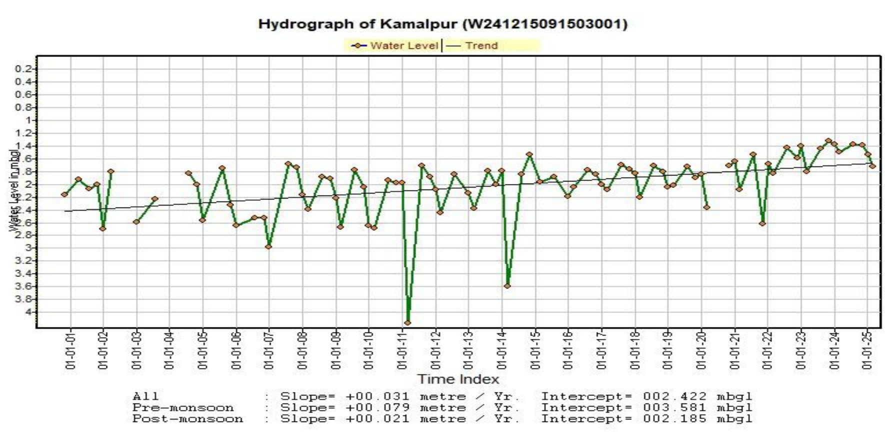
viii.


Hydrograph of Abhanga (W240253091502001)
Water Level
Trend
Water Level in mbgl
Time Index
All : Slope= +00.015 metre / Yr. Intercept= 003.087 mbgl
Pre-monsoon : Slope= +00.027 metre / Yr. Intercept= 004.676 mbgl
Post-monsoon : Slope= +00.006 metre / Yr. Intercept= 002.298 mbgl

ix.


Hydrograph of Ambassa (W235455091520001)
Water Level
Trend
Water Level in mbgl
Time Index
All : Slope= +00.046 metre / Yr. Intercept= 002.953 mbgl
Pre-monsoon : Slope= +00.168 metre / Yr. Intercept= 008.732 mbgl
Post-monsoon : Slope= +00.030 metre / Yr. Intercept= 002.276 mbgl

x.


Hydrograph of Kamalpur (W241215091503001)
Water Level
Trend
Water Level in mbgl
Time Index
All : Slope= +00.031 metre / Yr. Intercept= 002.422 mbgl
Pre-monsoon : Slope= +00.079 metre / Yr. Intercept= 003.581 mbgl
Post-monsoon : Slope= +00.021 metre / Yr. Intercept= 002.185 mbgl

xi.

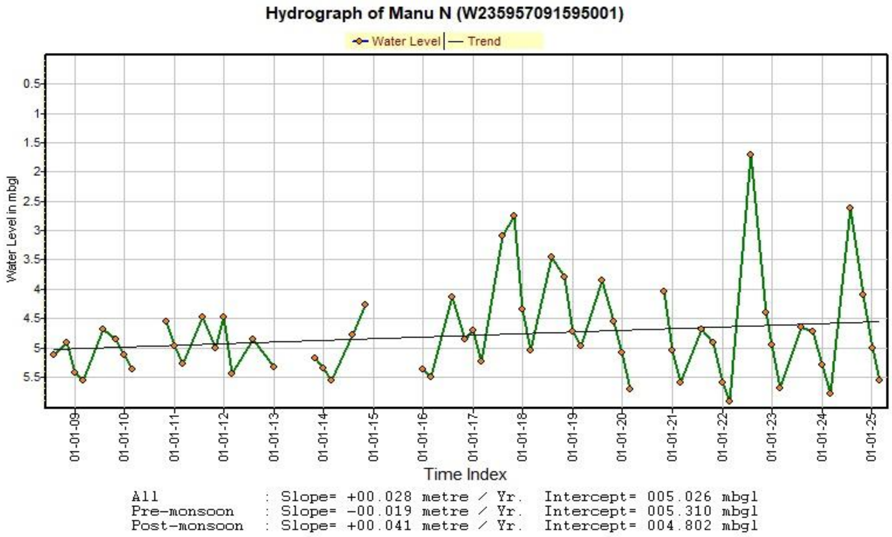


Figure 2 7: NHNS well Hydrographs of Dhalai District, Tripura

There has not been any significant decline of Water Level in whole of Tripura. The Long term water level trends shows an increase in Water level in most of the wells across Tripura.

Occurrences of Ground Water in Shallow Aquifers: Shallow aquifers generally extend within the depth range of 5 to 30 m bgl. In shallow aquifer, ground water generally occurs under unconfined condition in small isolated zones in the Latiabil – Abhanga – Santirbazar (Maharani) area and in Lambucherra – Nabinbari area.

Occurrences of Ground Water in Deeper Aquifers: In deeper aquifers ground water occurs under semi-confined to confined conditions. Most of the heavy duty ground water abstraction structures for different purposes are tapping these deeper aquifers along eastern side of Dhalai river (from Bhatkhowri (Santirbazar) to Bilascherra) and found to be in artesian condition. The deeper artesian zone is also found in Ambasa area, at Jagannathpur and another at Harincherra (in Gandacherra valley). The piezometric head in wells varies from 0.40 to 4 m agl. Discharge varies from 0.04 to 2 lps during pre-monsoon and from 0.19 to 3.5 lps during post-monsoon (during 2023 – 24).

3. THE SPRING INVENTORY IN DHALAI DISTRICT, TRIPURA

3.1. INTRODUCTION:

With the overwhelming response from the State Government of Tripura for our earlier published report on “Spring Study and its Management in Jampui Hill, North Tripura Dist., Tripura”, (https://cgwb.gov.in/cgwbpnm/publication-detail/1550) carried out under the Annual Action Plan, 2020-21, this office decided to undertake the Spring Study in the Dhalai Dist. of Tripura in in the Financial Year, 2023-24 (AAP 2023-24). However, owing to the staff and other resources constraints, the duration was extended for the FY 2024-25 (AAP 2024-25).

The Initial inventory in the Month of April & May, 2023 was about 16 Springs which was gradually increased to 19 and then to 38 in the AAP 2024-25 along with 4 Artesian wells in the Area.

Discharges of the Spring were measured as per the availability of Man Power and Vehicle over the two (2) Plan Years. The details of the Location along with other parameters including Discharges has been summerised in the Annexures (11.1, 11.2 & 11.3).

3.2. DISCHARGE MEASUREMENT:

Spring discharge measurement is essential for understanding the quantity and sustainability of groundwater emerging from a spring. Several techniques, both simple and advanced, are used to measure spring discharge depending on the terrain, flow rate, and available resources.

The most commonly used methods:

3.2.1. Volumetric Method

- **Best for:** Small springs with low discharge.
- **How it works:** Collect water in a container of known volume and measure the time taken to fill it.
- **Formula:** Discharge (Q)=Volume / Time
- **Units:** Litres per second (L/s) or cubic meters per second (m^3/s).

Figure 3-1: Volumetric method of discharge measurement

3.2.2. Weir Method

- **Best for:** Moderate flows.
- **How it works:** A weir (notched barrier) is placed across the spring flow, and the height of water above the crest is measured.
- **Common types:**
    - Rectangular Weir
    - V-Notch (Triangular) Weir at a fixed angle (45^0 ,60^0 ,90^0 or 120^0)
- **Advantage:** Accurate for small to medium flows when properly installed and maintained.

Figure 3-2: Weir method of discharge measurement

3.2.3. Float Method

- **Best for:** Open channels where direct measurement is difficult.
- **How it works:** A floating object is timed as it moves over a known distance; combined with cross-sectional area to estimate flow.
- **Formula:** **Q= A × V**

  Where *A* is cross-sectional area, *V* is velocity.
- **Note:** Less accurate due to surface velocity assumptions.

3.2.4. Salt Dilution Method

- **Best for:** Turbulent or inaccessible flows (e.g., where physical measurement is hard).
- **How it works:** A known quantity of salt is added to the flow and conductivity is measured downstream.
- **Used in:** Hydrological studies and hilly terrain.

3.2.5. Tracer Method

- **Best for:** Scientific studies and long-term monitoring.
- **How it works:** Harmless tracers (dyes, chemicals) are introduced and their concentration over time is analyzed downstream.
- **Use:** More for understanding flow paths and timing than just discharge

3.2.6. Installation of Flow Meters (advanced)

- **Best for:** Long-term monitoring in critical springs.
- **Types:** Ultrasonic, electromagnetic, or mechanical flow meters (flumes etc).
- **Advantage:** Real-time data and higher precision, though costlier.

Figure 3-3: Flow meters

Figure 3-4: Flume method of discharge measurement

In the present study, the volumetric measurement discharges in the springs were carried out using Volumetric and Weir method as described above.

3.3. DETAILED INVENTORY:

3.3.1. 43 Miles Springs (NH-8), (TR/KH/01)

ID:	TR/KH/01	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location:	**Lattitude**	**Longitude**
	23.90347	91.75220
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0131	0.0921
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: 43 Miles Springs (NH-8)

The Spring is located along NH-8 at 43 Miles Village. This spring has a Spring Chamber, Located along the road. The source is about 20m behind from the drainage channel.

3.3.2. 44 Miles Spring, (TR/KH/04)

ID:	TR/KH/04	
Type:	Fracture Spring	
Dependency:	Yes, for Drivers/ Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	No
Location:	**Lattitude**	**Longitude**
	23.90051	91.75797
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0128	0.2300
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: 44 Miles Spring

The Spring is located along NH-8 at 44 Miles Village, A Blue Pipe connected for water collection, Located in between two Hillock in the fracture zone.

3.3.3. 47 Miles Spring, (TR/KH/03)

ID:	TR/KH/03	
Type:	Contact Spring	
Dependency:	Yes, for Drivers/ Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	No
Location:	**Lattitude**	**Longitude**
	23.89007	91.76943
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0070	0.2735
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 8th Order	Post: 6th Order

Description: 47 Miles Spring

The Spring is located along NH-8 at 47 Miles Village, White Pipe near the Culvert, The Spring is on the Top of the Hillock and water is collected through the pipe.

3.3.4. Bachhamura Spring-1 (NH 208), (TR/DH/19)

ID:	TR/DH/19	
Type:	Contact Spring	
Dependency:	Yes, for Drivers/ Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10289	91.88827
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0102	0.0195
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Bachhamura Spring-1 (NH 208)

The Spring is located along NH-208, Narrow elongated Path with a Hole for the water to comeout

3.3.5. Bachhamura-2 Spring, (TR/DH/21)

ID:	TR/DH/21	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10254	91.89066
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0093	-
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	-

Description: Bachhamura-2 Spring

The Spring is located along NH-208, Spring Flowing in both the directions from the spring outlet towards the Road

3.3.6. Bachhamura-3 Spring, (TR/DH/23)

ID:	TR/DH/23	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10645	91.87817
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0169	-
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	-

Description: Bachhamura-3 Spring

The Spring is located along NH-208, A wet Patch below the Zebra Strip

3.3.7. Bachhamura-4, Dry Spring, (TR/DH/24)

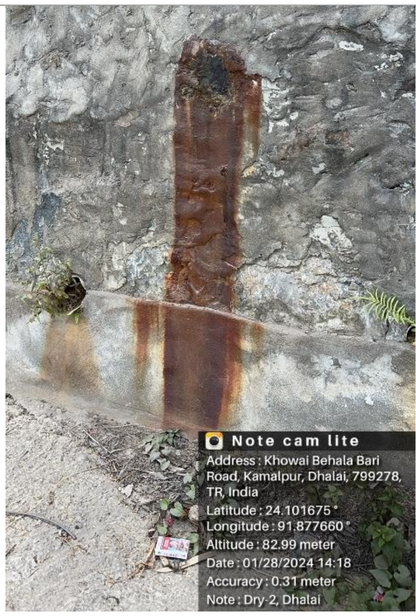
ID:	TR/DH/24	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10186	91.87763
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	Dry	Dry
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	-

Description: Bachhamura-4, Dry Spring

The Spring is located along NH-208, Dry, Dark Iron Stain with Hole inbetween

3.3.8. Bachhamura-5, Dry Spring, (TR/DH/25)

ID:	TR/DH/25	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10168	91.87766
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	Dry	Dry
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	-



Description: Bachhamura-5, Dry Spring

The Spring is located along NH-208, Dry, Dark Patch with No Hole

3.3.9. Bachhamura-6 Spring, (TR/DH/22)

ID:	TR/DH/22	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10160	91.87768
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	-	-
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	-

Description: Bachhamura-6 Spring

The Spring is located along NH-208, A small Spring below a Dark Iron Stained Dry Patch. The spring by the side is not measurable.

3.3.10. Bachhamura-7 Spring, (TR/DH/31)

ID:	TR/DH/31	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10133	91.87787
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0397	0.0549
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Bachhamura-7 Spring

The Spring is located along NH-208, Under the Green Sheet covering Hills, Just before the Bridge

3.3.11. Bachhamura-8, (TR/DH/32)

ID:	TR/DH/32	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location:	**Lattitude**	**Longitude**
	24.10381	91.88957
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0286	0.0549
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Bachhamura-8

The Spring is located along NH-208, A new discharge coming way far and goes below Bachhamura-1 Spring

3.3.12. Batapara Spring, (TR/DH/17)

ID:	TR/DH/17	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location:	**Lattitude**	**Longitude**
	23.74977	91.80360
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0351	0.0267
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Batapara Spring

Along the River under a under construction Bridge. The water gets collected in the sandstone tank.

3.3.13. Bishwarampara Spring, Left small Cherra, (TR/DH/07)

ID:	TR/DH/07	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location:	**Lattitude**	**Longitude**
	23.80710	91.98068
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0406	0.1675
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: Bishwarampara Spring, Left small Cherra

Below the Bridg, the Left Stream of Cherra

3.3.14. Bishwarampara Spring, Whole Cherra, (TR/DH/34)

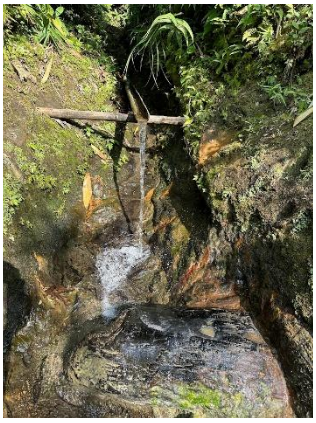
ID:	TR/DH/34	
Type:	Cherra (Rivlet)	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location:	**Lattitude**	**Longitude**
	23.80710	91.98068
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	-	-
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	-

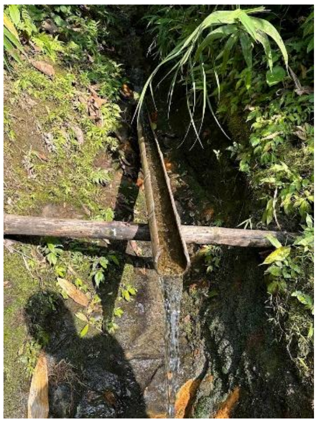
Description: Bishwarampara Spring, Whole Cherra

Below the Bridge, It's the discharge of the whole Cherra/stream

3.3.15. Chiching Charra Spring 1, Ratu Ruwaja Para, (TR/DH/13)

ID:	TR/DH/13	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.97333	92.05091
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.6460	1.5723
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 5^{th} Order	Post: 5^{th} Order



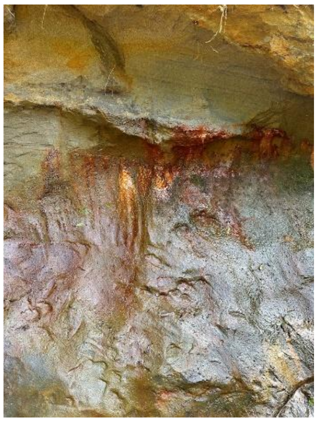


Description: Chiching Charra Spring 1, Ratu Ruwaja Para

Main Spring with High Discharge, Black Fossil Wood. This can be used as a water supply scheme.

3.3.16. Chiching Charra Spring 2, (TR/DH/20)

ID:	TR/DH/20	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.97332	92.05085
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0630	0.2193
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7^{th} Order	Post: 6^{th} Order



Description: Chiching Charra Spring 2

Just infront of the First spring, with huge Iron stain

3.3.17. GaganChaudhuryPara-1 Spring, (TR/DH/11)

ID:	TR/DH/11	
Type:	Depression Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	Yes
Location	**Lattitude**	**Longitude**
	23.82816	91.89470
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	-	-
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	-	-

Description: GaganChaudhuryPara-1 Spring

The Spring is bout 10 to 15 m below the village, Yellow Sandstone adjacent to the pond.

3.3.18. GaganChaudhuryPara-2 Spring, (TR/DH/12)

ID:	TR/DH/12	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location	**Lattitude**	**Longitude**
	23.82918	91.88949
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	-	0.00001
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	-	Post: 8th Order

Description: GaganChaudhuryPara-2 Spring

The Spring is bout 9 to 10 m below the village, Dark Shale and is the only source of Water for the village

3.3.19. Harincharra Spring, (TR/DH/06)

ID:	TR/DH/06	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.85146	91.88055
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.1142	0.3837
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 6^{th} Order	Post: 6^{th} Order

Description: Harincharra Spring

Only the Main Channel of the Array of Springs

3.3.20. Harincharra Spring (Composite Discharge), (TR/DH/30)

ID:	TR/DH/30	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.85146	91.88055
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.8993	0.4580
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 5^{th} Order	Post: 6^{th} Order

Description: Harincharra Spring (Composite Discharge)

The Total Discharge of the Springs from all its mouth(three to four outlet combined).

3.3.21. Jogendrapara Spring (Mostly Dry), (TR/DH/04)

ID:	TR/DH/04	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.80026	91.98068
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	Dry	-
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	-

Description: Jogendrapara Spring (Mostly Dry)

On to, Narrow Road, RHS of Road, May be a seasonal spring high discharge water outlet

3.3.22. Kathalbari Spring 1 (Chandraipara), (TR/DH/02)

ID:	TR/DH/02	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.91997	91.89004
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0402	0.0805
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: Kathalbari Spring 1 (Chandraipara)

Along the river, by the side of Agricultural Field & Bridge , Left when you get down, high iron stain.

3.3.23. Kathalbari Spring 2, (TR/DH/26)

ID:	TR/DH/26	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.92015	91.89012
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0156	0.0149
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Kathalbari Spring 2

Along the river, by the side of Agricultural Field & Bridge, same side of 1, Right, when u get down, A Small Pool of two Outlet, one with Fe Stain

3.3.24. Kathalbari Spring 3, (TR/DH/27)

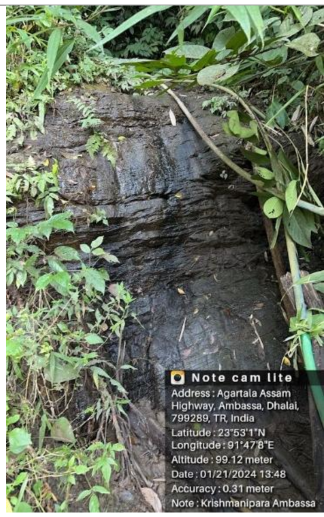
ID:	TR/DH/27	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.91982	91.88991
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0212	0.0124
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Kathalbari Spring 3

Along the river, by the side of Agricultural Field & Bridge, opposite side of 1

3.3.25. Krishnamanipara-1 Spring (NH-8), (TR/DH/01)

ID:	TR/DH/01	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.88318	91.78494
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0562	2.0408
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 5th Order



Description: Krishnamanipara-1 Spring (NH-8)

Just at the border of Dhalai & Khowai Dist in the curve, all discharge of the spring, directly taken to village for Supply, can be developed into a water supply scheme.

3.3.26. Krishnamanipara-2 Spring (NH-8), (TR/DH/28)

ID:	TR/DH/28	
Type:	Fracture Spring	
Dependency:	Yes for Drivers/Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.88485	91.78586
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0523	0.6230
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: Krishnamanipara-2 Spring (NH-8)

About 250 m from Border of Dhalai & Khowai Dist , along the road

3.3.27. Narsiraipara Spring, (TR/DH/08)

ID:	TR/DH/08	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.69147	91.85296
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0940	0.2843
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 6th Order	Post: 6th Order

Description: Narsiraipara Spring

Narrow Cave Like Structure, with water pondage. Way below the road, Grey Sandstone, can be developed into a water supply scheme.

3.3.28. Nunacherra Spring, (TR/DH/09)

ID:	TR/DH/09	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.78743	91.85537
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0084	0.0216
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Nunacherra Spring

Near Our NHNS Well, very Little Discharge, like a seepage spring. There is a seepage spring just adjacent to it and also another spring to the front (towards the Road) with heavy discharge. Difficult to masure. The heavy discharge spring along the road can be developed into a water supply scheme.

3.3.29. Nutangram Spring, (TR/DH/14)

ID:	TR/DH/14	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.86863	92.00636
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0138	0.0287
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order


Description: Nutangram Spring

A small Cherra Left to the Main Cherra, Take Left from shop, way below, difficult to access

3.3.30. Parkaraipara Spring, (TR/DH/10)

ID:	TR/DH/10	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.83200	91.89168
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0043	0.0189
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 8th Order	Post: 7th Order

Description: Parkaraipara Spring
Way below the Village Level (Water deposits in Tank)

3.3.31. Saikarbari Spring (NH 208), (TR/DH/18)

ID:	TR/DH/18	
Type:	Contact Spring	
Dependency:	Yes for Drivers/Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location	**Lattitude**	**Longitude**
	24.10889	91.91077
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0082	0.0548
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 7th Order

Description: Saikarbari Spring (NH 208)
Running Spring, a Pipe by the side of Road, near a Zebra Strip

3.3.32. Saikarbari Spring-2 (NH-208), Dry, (TR/DH/29)

ID:	TR/DH/29	
Type:	Contact Spring	
Dependency:	No	
Vulnerability to damage:	**Spring**	**Springshed**
	Yes	Yes
Location	**Lattitude**	**Longitude**
	24.11137	91.91166
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	Dry	0.00001
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	-	Post: 8th Order

Description: Saikarbari Spring-2 (NH-208), Dry
Dry, A cement sink water way below.

3.3.33. Saya kumar Para Spring, (TR/DH/05)

ID:	TR/DH/05	
Type:	Depression Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	Yes
Location	**Lattitude**	**Longitude**
	23.82311	91.98372
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	-	-
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	-	-

Description: Saya kumar Para Spring

Along the River, Big Sandstone tank. Not measurable. The spring is along a Nala joining main river. One has to climb down to the river.

3.3.34. Sindhu Kumar (SK) Para Spring (NH-8), (TR/DH/03)

ID:	TR/DH/03	
Type:	Fracture Spring	
Dependency:	Yes, Villagers/Travellers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.94665	91.95963
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0336	0.0912
Geology:	**Group**	**Formation**
	Surma	Bokabil
Mainzer's Classification:	**Magnitude:**	
	Pre: 7^{th} Order	Post: 6^{th} Order

Description: Sindhu Kumar (SK) Para Spring (NH-8)

The Spring is located along NH-8, with a big tank on the road connected by a pipe from spring

3.3.35. Thalcharra Spring (Small Outlet), (TR/DH/15)

ID:	TR/DH/15	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.71281	92.04071
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0196	0.1040
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: Thalcharra Spring (Small Outlet)

Near the Thalchera waterfall, a small outlet to the right which going to the fall along the cherra.

3.3.36. Thalcherra Water Fall, Cherra Discharge, (TR/DH/33)

ID:	TR/DH/33	
Type:	Fracture Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.71281	92.04071
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.1892	0.2843
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 6th Order	Post: 6th Order

Description: Thalcherra Water Fall, cherra/fall Discharge

Whole cherra/fall, discharge.

3.3.37. Udasinghpara Cherra Discharge, (TR/DH/35)

ID:	TR/DH/35	
Type:	Cherra (Rivlet) / Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.73132	91.87566
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.1160	0.1728
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 6th Order	Post: 6th Order


Description: Udasinghpara Cherra Discharge

Way below, one has to go down near the Church, down and Left, LHS of the Cherra (curves)

3.3.38. Udasinghpara Spring, (TR/DH/16)

ID:	TR/DH/16	
Type:	Contact Spring	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
	No	No
Location	**Lattitude**	**Longitude**
	23.73132	91.87566
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0252	0.1728
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	Pre: 7th Order	Post: 6th Order

Description: Udasinghpara Spring

Way below, one has to go down near the Church, down and Left, LHS of the Cherra (curves)

3.3.39. 45 Miles Artesian Well, (TR/KH/02)

ID:	TR/KH/02	
Type:	Artesian Well	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
Location	**Lattitude**	**Longitude**
	23.90068	91.76425
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.0101	0.0155
Geology:	**Group**	**Formation**
	Surma	Upper Bhuban
Mainzer's Classification:	**Magnitude:**	
	NA	NA

Description: 45 Miles Artesian Well

Near to our NHS Well , the Artesian Well

3.3.40. Harinchera Artesian Well, (TR/DH/36)

ID:	TR/DH/36	
Type:	Artesian Well	
Dependency:	Yes, Villagers	
Vulnerability to damage:	**Spring**	**Springshed**
Location	**Lattitude**	**Longitude**
	23.85183	91.88205
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**
	0.2924	0.6667
Geology:	**Group**	**Formation**
	Tipam	Tipam sandstone
Mainzer's Classification:	**Magnitude:**	
	NA	NA

Description: Harinchera Artesian Well

Public Water Supply Tubewell, Located near the village market

3.3.41. Iladhan Artesian Well, (TR/DH/37)

ID:	TR/DH/37		
Type:	Artesian Well		
Dependency:	Yes, Villagers		
Vulnerability to damage:	**Spring**	**Springshed**	
Location	**Lattitude**	**Longitude**	
	23.90231	91.86684	
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**	
	0.4480	0.8977	
Geology:	**Group**	**Formation**	
	Dupitila	Dupitila	
Mainzer's Classification:	**Magnitude:**		
	NA	NA	

Description: Iladhan Artesian Well

Along the Roadside, Near the wall, Our Geophysical Site.

3.3.42. Vidyajoy Para Artesian Well, (TR/DH/38)

ID:	TR/DH/38		
Type:	Artesian Well		
Dependency:	Yes, Villagers		
Vulnerability to damage:	**Spring**	**Springshed**	
Location	**Lattitude**	**Longitude**	
	23.96325	92.04653	
Discharge: (in lps)	**(Pre) Mar, 24**	**(Post) Nov, 2024**	
	0.2072	0.2749	
Geology:	**Group**	**Formation**	
	Tipam	Tipam sandstone	
Mainzer's Classification:	**Magnitude:**		
	NA	NA	

Description: Vidyajoy Para Artesian Well

Along the road side on the way to Chichincherra

4. SPRING HYDROGRAPH ANALYSIS & INTERPRETATION

4.1. INTRODUCTION:

Spring hydrograph gives valuable information on response of spring flow with rainfall events, seasonal variation of spring discharge and also behaviour of the spring during lean season. Spring hydrograph can be interpreted to know the aquifer properties, extent of recharge areas, impact of climate change, etc. Various workers have coined different parameters for analysis of spring hydrograph.

4.2. MATERIALS AND METHODS

Spring discharge of 21 Nos. of springs out of the total 38, in Dhalai and Khowai districts were monitored regularly on monthly basis from April 2023 to March 2025. However, there are few months where monthly monitoring could not be carried out because of logistic constrains; otherwise, the data sets are continuous.

Following hydrograph analysis were carried out

i. Rainfall vs. discharge
ii. Recession curve analysis

4.2.1. Rainfall vs. discharge

The discharge of springs is plotted with rainfall to qualitatively define the relation between discharge and rainfall. The springs inventoried in Manu valley is compared with rainfall recorded at Chawmanu rain gauge station whereas rainfall of Kamalpur valley is compared with KVK Dhalai rain gauge station. The Kamalpur and Manu valleys are separted by the Longtarai Hill. The plotting is done only for prominent springs with comparatively high discharge. From the graph lag time between peak rainfall and peak discharge was worked out.

4.2.2. Recession curve analysis

Recession curve is the part of discharge hydrograph that extends from a peak discharge to the base of the next rise and corresponds to a period with no significant precipitation. Analysis of recession curve helps to understand spring aquifer characteristics and also help to separate different flow components. The analysis also helps to predict discharge during low flow condition. Thus, recession curve analysis is an integral part for sustainable spring water management.

In the recession curve, generally there exists an initial section where the decrease rate is more marked called decrease curve, followed by a more slowly decreasing flow, called depletion curve.

Two well-known mathematical formulas that describe the falling limb of hydrographs and the base flow were proposed by Boussinesq (1904) and Maillet (1905). Both equations give the dependence of the flow at specified time (Q_t) on the flow at the beginning of recession (Q_0). The Boussinesq equation is of hyperbolic form:

$$Qt= Q_0 / [1+\alpha(t-t_0)]^2 \text{----------}(1)$$

where Q_t is spring discharge at specified time and Q_0 spring discharge at the beginning of recession. α is the coefficient of discharge (or recession coefficient), which depends on the aquifer's properties.

The Maillet equation, which is more commonly used, is an exponential function:

$$Q=Q_0 \times e^{-\propto(t-to)} \quad \text{———} \quad (2)$$

The parameter α in both equations represents the coefficient of discharge (or recession coefficient) which depends on the aquifer's transmissivity and specific yield.

Maillet equation, when plotted on a semi-log diagram, is a straight line with the coefficient of discharge (α) being its slope

$$\log Q_t = \log Q_0 - 0.4343a(t-t_0) \quad \text{———} \quad (3)$$

or, $$\propto = \frac{\log Q_0 - \log Q_t}{0.4343 \times (t-t_0)} \quad \text{———} \quad (4)$$

dimension of α is day^{-1}

4.3. RESULTS AND DISCUSSION

4.3.1. Rainfall vs. discharge:

It is observed that there is good correlation between rainfall and spring discharge. Spring rising limb starts from April/May when pre-monsoon rain starts and during mid-monsoon peak discharge is observed. After cessation of rainfall spring discharge also dwindles and gradually discharge decreases till the next rainfall. It is also observed that precipitation of less than 100mm does not have any bearing on spring discharge.

In Kamalpur Valley, peak rainfall was recorded during the month of June in 2024 and July in 2024 whereas peak spring discharge of springs was observed during August in 2024. In general one month lag is observed between peak rainfall and peak spring discharge (Fig.4.1).

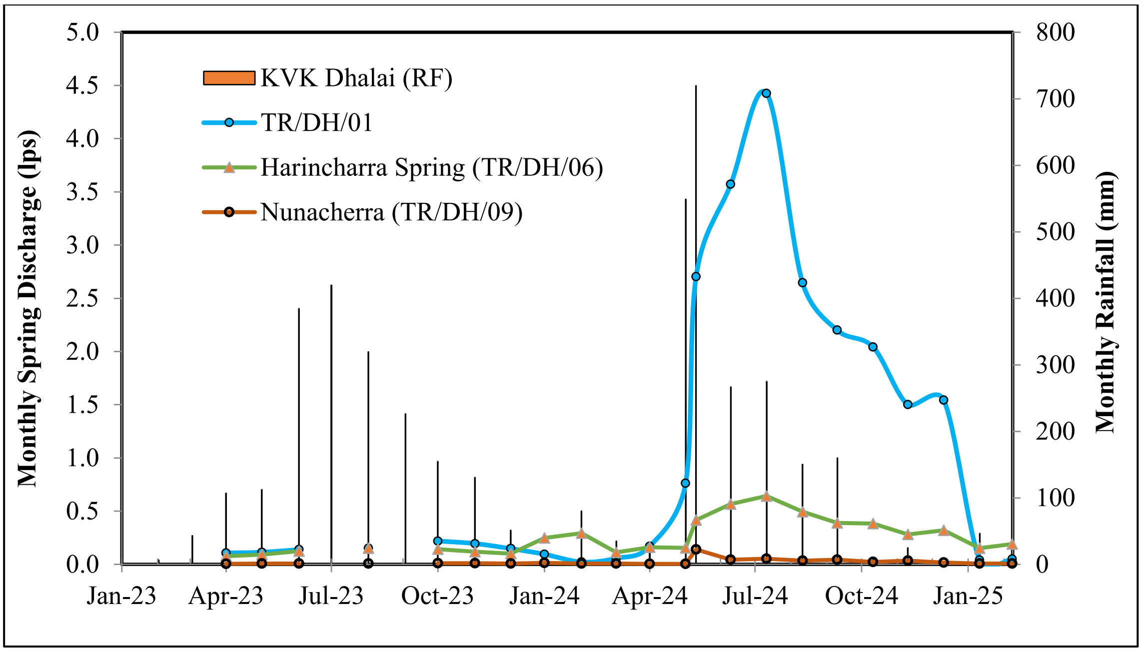


Figure 4-1: Relation between rainfall and spring discharge in Kamalpur Valley, Dhalai District, Tripura

In Manu Valley also, a time lag of one month is noticed between peak rainfall and peak spring discharge (Fig.4.2).

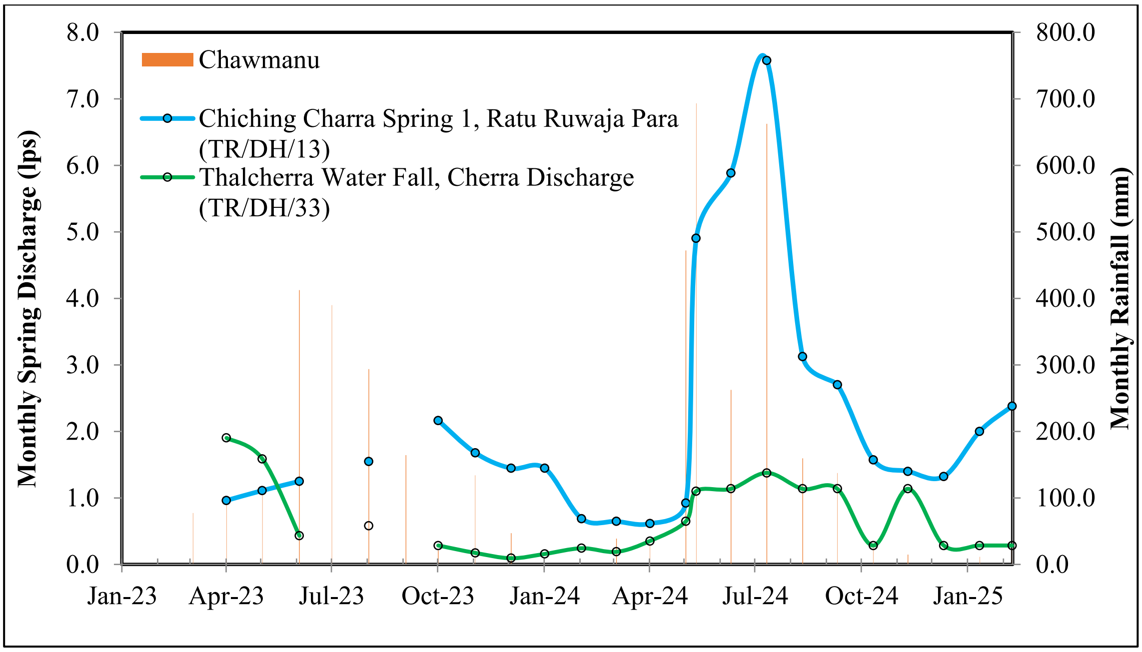


Figure 4-2: Relation between rainfall and spring discharge in Manu Valley, Dhalai District, Tripura

4.3.2. Recession curve analysis

The spring discharge data of Dhalai district were analyzed for the years between 2023 and 2024, by the best fit of the observed curves with the Maillet's equation. The hydrograph data of the springs were plotted on semi-logarithmic graphs and the recession coefficients (α) were estimated by Equation (3). The results referring to the representative years are presented in Table 4.1 & 4.2 and the discharge data at Table 4:6.

Table 4:1: Summary of the main parameters characterizing the recession curves of springs of Manu Valley, Dhalai District, Tripura

Spring ID	2023			2024			Average
	Q_0 (m^3/s)	Q_1(m^3/s)	α (day^{-1})	Q_0 (m^3/s)	Q_1(m^3/s)	α (day^{-1})	α (day^{-1})
TR/DH/03	0.000017	0.000014	0.00394	0.00016	0.000075	0.00825	0.0061
TR/DH/13	0.0022	0.001445	0.00662	0.0031	0.0014	0.00873	0.00768
TR/DH/14	0.000017	0.000013	0.00371	0.000037	0.00002	0.00669	0.0052
TR/DH/15	0.000024	0.000016	0.00609	0.000224	0.00008	0.01119	0.00864
TR/DH/20	0.00031	0.00018	0.006	0.000104	0.00007	0.00652	0.00626

Table 4:2: Summary of the main parameters characterizing the recession curves of springs of Kamalpur Valley, Dhalai District, Tripura

Spring ID	2023			2024			Average
	Q_0	Q_1	α (day^{-1})	Q_0 (m^3/s)	Q_1(m^3/s)	α (day^{-1})	α (day^{-1})
TR/DH/01	0.000219	0.000147	0.0065	0.002646	0.0015	0.00617	0.006335
TR/DH/02	0.000046	0.000034	0.00511	0.00014	0.000067	0.00805	0.00658
TR/DH/06	0.000141	0.000101	0.00549	0.000495	0.00028	0.00619	0.00584
TR/DH/07	0.000055	0.000037	0.00622	0.000387	0.00011	0.01367	0.009945
TR/DH/08	0.000223	0.000154	0.26875	0.00058	0.0002	0.01157	0.14016
TR/DH/09	0.000011	0.000009	0.00353	0.000035	0.000018	0.00735	0.00544
TR/DH/10	0.000009	0.000007	0.00299	0.000032	0.000017	0.00678	0.004885
TR/DH/16	0.000031	0.000021	0.0067	0.001136	0.00021	0.01835	0.012525
TR/DH/17	0.000021	0.000017	0.00368	0.000064	0.000025	0.00774	0.00571
TR/DH/18	0.000007	0.000005	0.00412	0.000099	0.000043	0.00904	0.00658
TR/DH/19	0.000048	0.000035	0.19441	0.000069	0.000014	0.01307	**0.10374**
TR/DH/27	0.000014	0.000012	0.0028	0.000016	0.000011	0.0042	0.0035
TR/DH/28				0.000757	0.00054	0.00367	0.00367
TR/DH/30	0.0013	0.0001	0.00453	0.001151	0.00025	0.0166	0.010565
TR/DH/31				0.000328	0.000042	0.02234	0.02234

TR/DH/32				0.000112	0.000042	0.00807	0.00807
TR/DH/33	0.00028	0.00009	**0.01838**	0.001136	0.00021	**0.01835**	**0.018365**
TR/DH/38				0.00029	0.000017	0.03081	0.03081

The Q_0 in m^3/s is the discharge from storage at the beginning of the recession whereas Q_1 is the end of recession period for a particular year. Q_0 and Q_1 of the same spring differ from year to year indicating that discharge is dependent on rainfall. In 2023 there was a drastic reduction of rainfall in Dhalai district which was reflected in spring discharge. On the contrary, the precipitation in 2024 was more than the 2023 and accordingly spring discharge as well as Q_0 and Q_1value of the same spring increases in 2024. In Dhalai district, it is observed that barring few springs recession coefficient of majority of the spring have low value which indicate that the aquifer possess low hydraulic conductivity value.

However, the recession coefficient, α (day^{-1}), is independent of precipitation rather it is dependent on aquifer properties, like transmissivity and hydraulic conductivity. α (day^{-1}) is directly proportional to hydraulic conductivity. Higher the hydraulic conductivity value higher is the recession coefficient and more quickly the aquifer depletes. Generally, recession coefficient value of the same spring does not vary with time.

4.3.3. Dynamic Reserve of spring

The volume of stored water in the saturated zone above the outflow spring level is termed the dynamic volume of the spring (Mangin 1975; Ford and Williams 1994).

Maillet's model assumes a linear aquifer system, where the discharge (Q) is directly proportional to the volume of water stored (V) in the aquifer. This leads to an exponential decay in discharge over time, as expressed by the equation (2).

That means V, with Q = αV, α is the recession coefficient

$$V = \frac{Q_0}{\propto}.86400\left(\frac{\mathrm{m}^3}{\mathrm{day}}\right) \dots\dots\dots\dots (5)$$

Where

V, is the storage capacity or dynamic reserve (m^3);

Q, is the groundwater discharge (m^3/s);

α, is the depletion constant (1/d).

For a given time period, $\Delta t = (t_0 - t_m)$, quantitative data about the dynamic reserve at the end of the period (f) may be calculated from the following equation:

$$Vm = Vo + R - Q \quad \dots\dots\dots\dots\dots\dots \quad (6)$$

where V_m = dynamic reserve at the end of the period *(tm)*;

V_o = dynamic reserve at the beginning of the period (r) (m_3);

R = groundwater recharge volume during the time period Δt (m^3);

Q = groundwater discharge volume during the time period Δt (m^3).

The volume of groundwater recharge during a water year will be:

$$R=Q\pm\Delta V……….(7)$$

where R = groundwater recharge volume during the water year (m^3);

Q = groundwater discharge volume during the water year (m^3); and

ΔV = dynamic reserve change during the water year (m^3).

4.4. RESULTS AND DISCUSSION

Dynamic reserve at the beginning of recession period and at the end of recession period was calculated for two valleys of Dhalai District, Tripura using equation (4). Total discharge for 2023 and 2024 was also calculated as per data provided in Table 4:6. Recharge during 2023 and 2024 were also estimated and provided in Table 4:3 to 4:5.

Table 4:3: Dynamic reserve and recharge of springs in Manu Valley, Dhalai District, Tripura in 2023 & 2024

2023								
Spring ID	**Q_0 (m^3/s)**	**Q_1(m^3/s)**	**α**	**V_0 (m^3)**	**V_1(m^3)**	**V_0-V_1 (m^3)**	**Q(m^3)**	**R=Q±ΔV (m^3)**
TR/DH/03	0.000017	0.000014	0.006095	240.98	198.46	42.52	331.52	374.04
TR/DH/13	0.0022	0.001445	0.007675	31186.22	20483.68	10702.54	34988.17	45690.71
TR/DH/14	0.000017	0.000013	0.0052	240.98	184.28	56.7	359.65	416.35
TR/DH/15	0.000024	0.000016	0.00864	340.21	226.81	113.4	470.86	584.26
TR/DH/20	0.00031	0.00018	0.00626	4394.42	2551.6	1842.82	1975.44	3818.26
					Total in m^3	12758		50883.6
					Total in ham	1.28		5.08836
2024								
TR/DH/03	0.00016	0.000075	0.006095	2268.09	1063.17	1204.92	3333.21	4538.13
TR/DH/13	0.0031	0.0014	0.007675	43944.22	19845.78	24098.44	82970.68	107069.1
TR/DH/14	0.000037	0.00002	0.0052	524.5	283.51	240.99	957.14	1198.13
TR/DH/15	0.000224	0.00008	0.00864	3175.32	1134.04	2041.28	4120.65	6161.93
TR/DH/20	0.000104	0.00007	0.00626	1474.26	992.29	481.97	8870.02	9351.99
					Total in m^3	28067.6		128319.3
					Total in ham	2.81		12.83

Table 4:4: Dynamic reserve and recharge of springs during 2023 in Kamalpur Valley, Dhalai District, Tripura

Spring ID	2023							
	Q_0 (m^3/s)	Q_1(m^3/s)	α	V_0 (m^3)	V_1(m^3)	V_0-V_1 (m^3)	Q(m^3)	R=Q±ΔV (m^3)
TR/DH/01	0.000219	0.000147	0.006335	2986.84	2004.86	981.98	2778245	2779227
TR/DH/02	0.000046	0.000034	0.00658	604.01	446.44	157.57	583646.8	583804.3
TR/DH/06	0.000141	0.000101	0.00584	2086.03	1494.25	591.78	2096464	2097056
TR/DH/07	0.000055	0.000037	0.009945	477.83	321.45	156.38	1025846	1026003
TR/DH/08	0.000223	0.000154	0.14016	137.47	94.93	42.54	2919955	2919997
TR/DH/09	0.000011	0.000009	0.00544	174.71	142.94	31.77	153578	153609.8
TR/DH/10	0.000009	0.000007	0.004885	159.18	123.81	35.37	136251.8	136287.2
TR/DH/16	0.000031	0.000021	0.012525	213.84	144.86	68.98	396545.4	396614.4
TR/DH/17	0.000021	0.000017	0.00571	317.76	257.23	60.53	329014.7	329075.3
TR/DH/18	0.000007	0.000005	0.00658	91.91	65.65	26.26	85515.68	85541.94
TR/DH/19	0.000048	0.000035	0.10374	39.98	29.15	10.83	882370.4	882381.2
TR/DH/27	0.000014	0.000012	0.0035	345.6	296.23	49.37	213323.3	213372.6
TR/DH/28			0.00367	0	0	0	3297080	3297080
TR/DH/30	0.0013	0.0001	0.010565	10631.33	817.79	9813.54	18041215	18051028
TR/DH/31			0.02234	0	0	0	0	0
TR/DH/32			0.00807	0	0	0	0	0
TR/DH/33	0.00028	0.00009	0.018365	1317.29	423.41	893.88	13082835	13083729
TR/DH/38			0.03081	0	0	0	0	0
Total recharge during 2023 (m^3)								46034806.74
Total recharge during 2023 (ham)								4603.48

Table 4:5: Dynamic reserve and recharge of springs during 2024 in Kamalpur Valley, Dhalai District, Tripura

Spring ID	2024							
	Q_0 (m^3/s)	Q_1 (m^3/s)	α	V_0 (m^3)	V_1(m^3)	V_0-V_1 (m^3)	Q(m^3)	R=Q±ΔV (m^3)
TR/DH/01	0.002646	0.0015	0.006335	36087.51	20457.77	15629.74	44178004	44193633
TR/DH/02	0.00014	0.000067	0.00658	1838.3	879.76	958.54	2504383	2505342
TR/DH/06	0.000495	0.00028	0.00584	7323.29	4142.47	3180.82	9304903	9308084

TR/DH/07	0.000387	0.00011	0.009945	3362.17	955.66	2406.51	7371439	7373845
TR/DH/08	0.00058	0.0002	0.14016	357.53	123.29	234.24	11009687	11009921
TR/DH/09	0.000035	0.000018	0.00544	555.88	285.88	270	892405.9	892675.9
TR/DH/10	0.000032	0.000017	0.004885	565.98	300.68	265.3	545293.9	545559.2
TR/DH/16	0.001136	0.00021	0.012525	7836.36	1448.62	6387.74	1091076	1097464
TR/DH/17	0.000064	0.000025	0.00571	968.41	378.28	590.13	1043435	1044025
TR/DH/18	0.000099	0.000043	0.00658	1299.94	564.62	735.32	5713754	5714490
TR/DH/19	0.000069	0.000014	0.10374	57.47	11.66	45.81	1356269	1356315
TR/DH/27	0.000016	0.000011	0.0035	394.97	271.54	123.43	303159.8	303283.3
TR/DH/28	0.000757	0.00054	0.00367	17821.47	12712.81	5108.66	20053758	20058867
TR/DH/30	0.001151	0.00025	0.010565	9412.82	2044.49	7368.33	24326651	24334020
TR/DH/31	0.000328	0.000042	0.02234	1268.54	162.44	1106.1	5796411	5797517
TR/DH/32	0.000112	0.000042	0.00807	1199.11	449.67	749.44	1652447	1653197
TR/DH/33	0.001136	0.00021	0.018365	5344.43	987.97	4356.46	17739231	17743587
TR/DH/38	0.00029	0.000017	0.03081	813.24	47.67	765.57	6433815	6434581
Total recharge during 2024 (m^3)						50282.14		161E+08
Total recharge during 2024 (ham)						5.02		16136.64

Dynamic reserve of five springs of Manu Valley during 2023 and 2024 are estimated as 1.27 and 2.81 ham respectively. Recharge of the same springs during 2023 and 2024 are nearly 5 and 13 ham respectively. In case of Kamalpur Valley dynamic reserve of 15 nos. of springs during 2023 and 2024 are estimated as nearly 1.3 and 5 ham respectively. Recharge of the same springs during 2023 and 2024 are nearly 5 and 16136 ham respectively.

It is observed that dynamic reserve of the five springs of Manu Valley is almost equal to dynamic reserve of the 15 springs in Kamalpur Valley while the spring recharge is more in Kamalpur Valley. This indicate that aquifer of Manu Valley is more permeable than Kamalpur Valley due to which dynamic reserve is more in the Manu Valley. Due to which the springs are more prone to deplete with time.

4.5. RECESSION HYDROGRAPH OF SPRINGS IN DHALAI DISTRICT, TRIPURA

4.5.1. Manu Valley

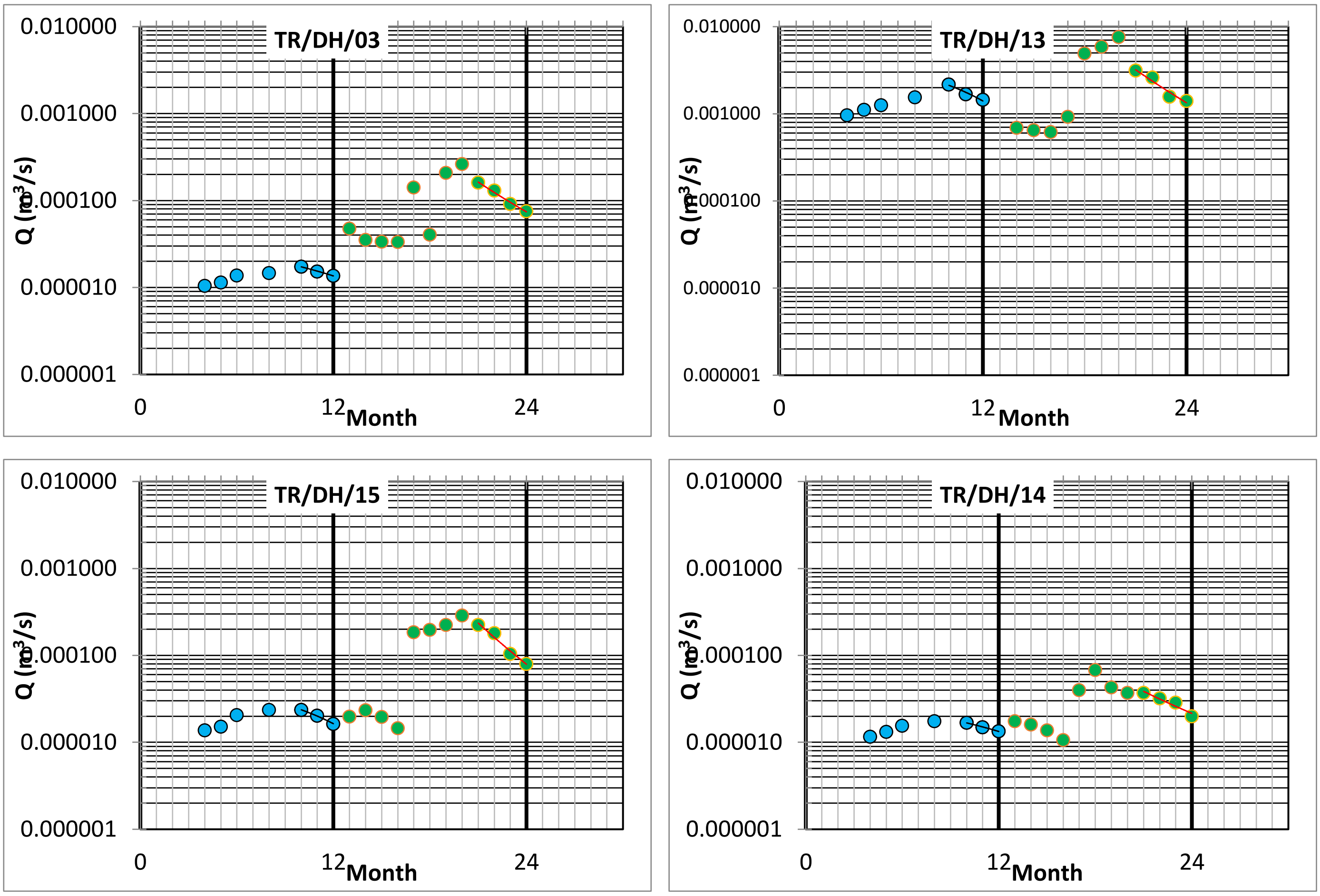
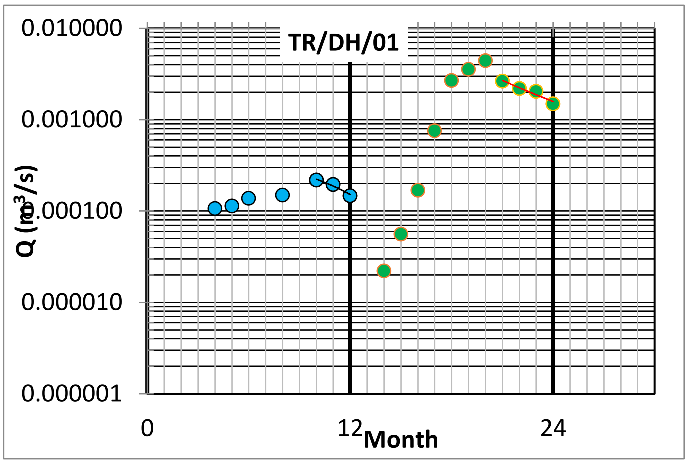
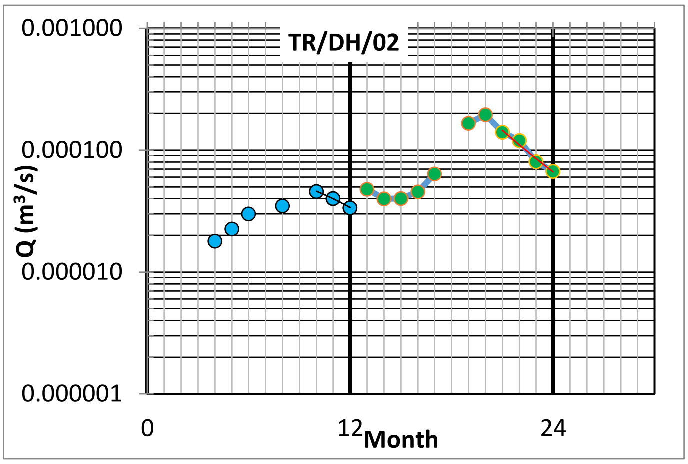
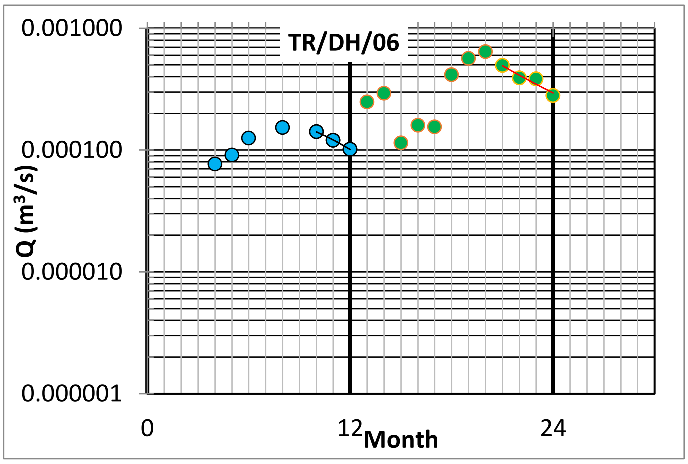


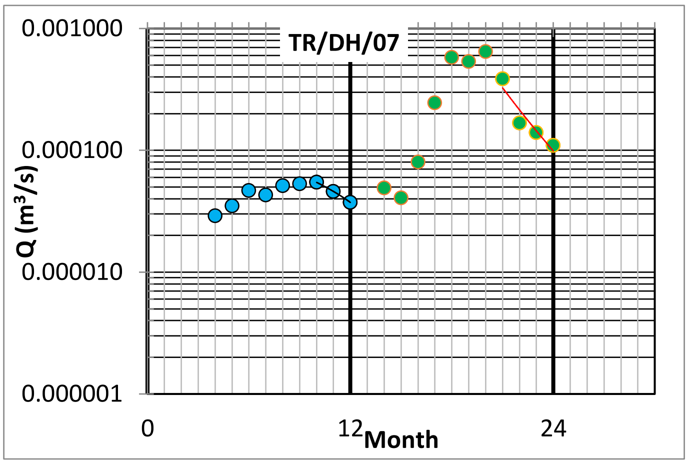
Figure 4-3: Recession hydrograph of springs of Manu Valley, Dhalai Disrict, Tripura.

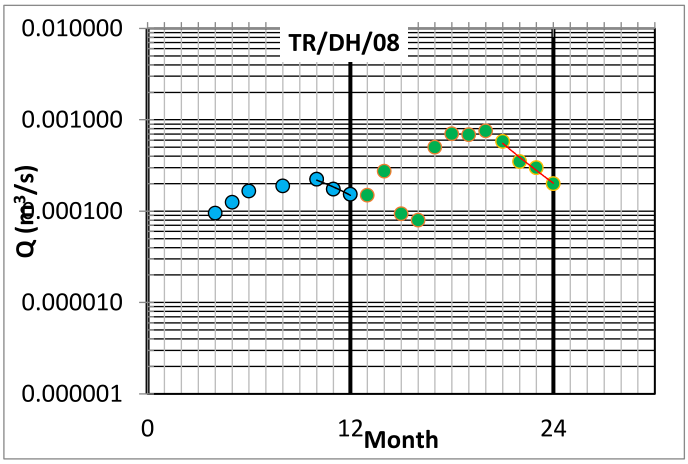
4.5.2. Kamalpur Valley

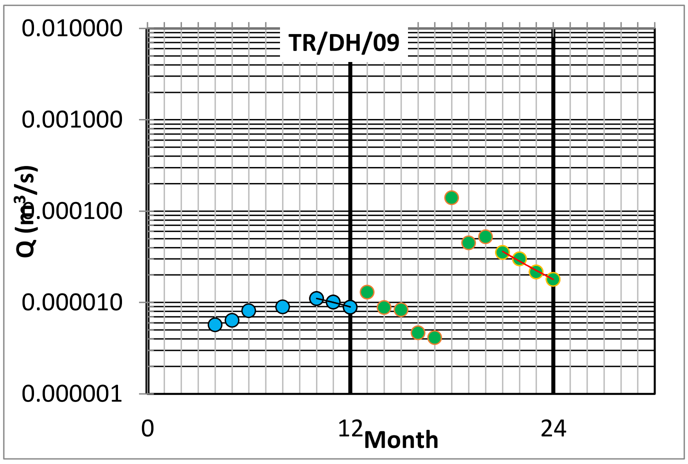


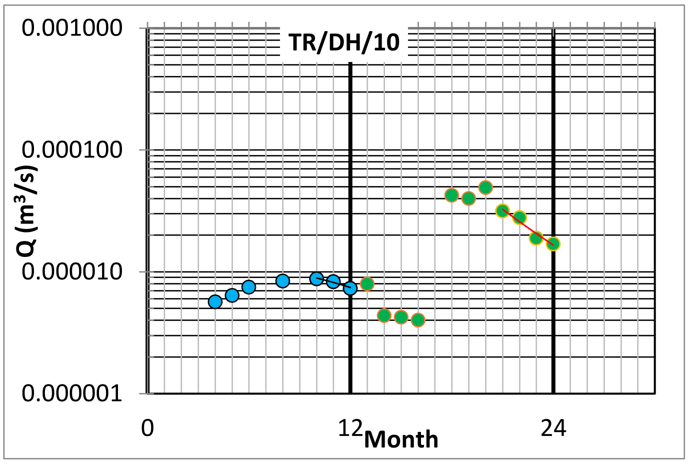








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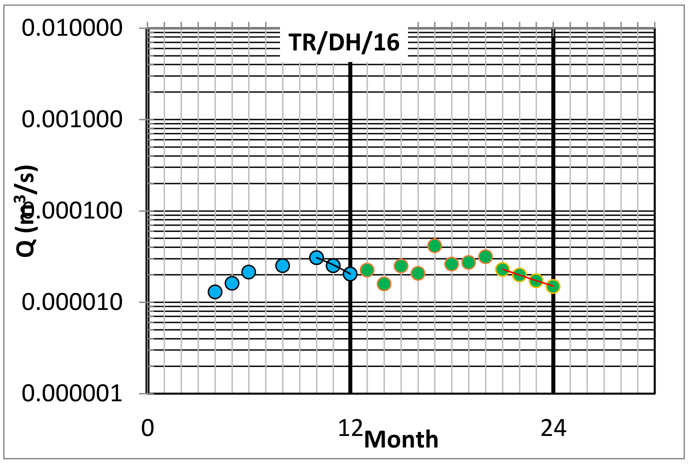
0.000100
0.000010
0.000001
Q (m3/s)
0
12
24
Month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0.001000
0.000100
0.000010
0.000001
Q (m3/s)
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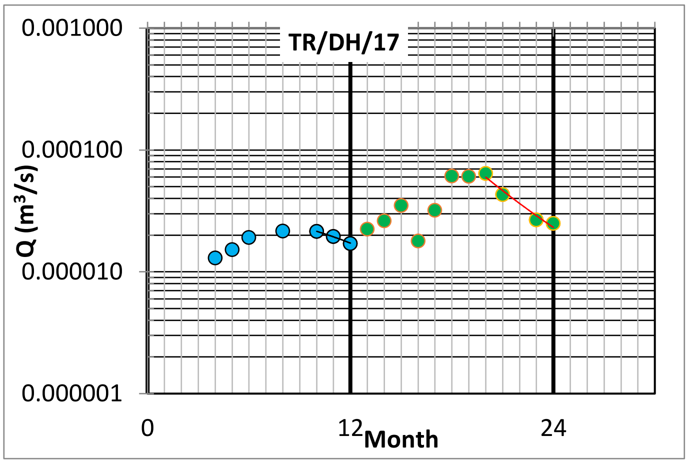
12
24
Month


TR/DH/17
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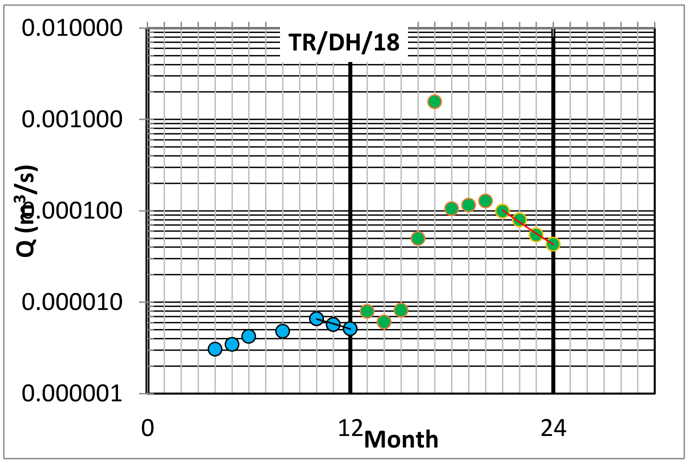
0.000100
0.000010
0.000001
Q (m3/s)
0
12
24
Month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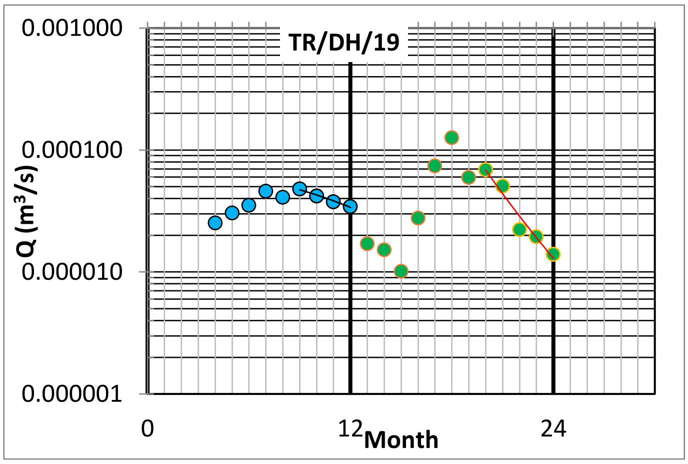
0.001000
0.000100
0.000010
0.000001
Q (m3/s)
0
12
24
Month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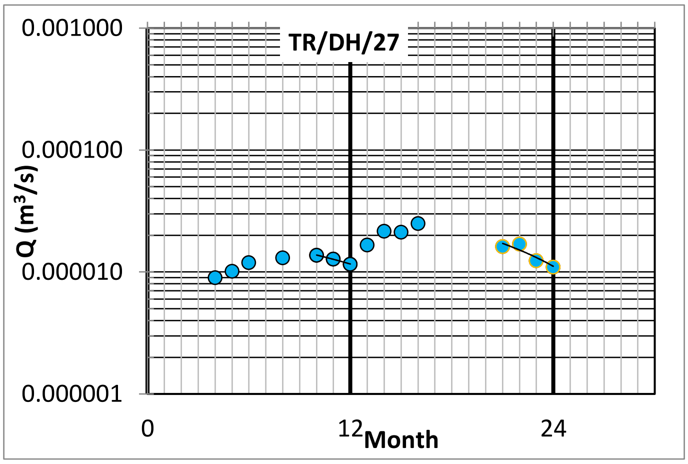
12
24
Month


TR/DH/27
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0.000100
0.000010
0.000001
Q (m3/s)
0
12
24
Month

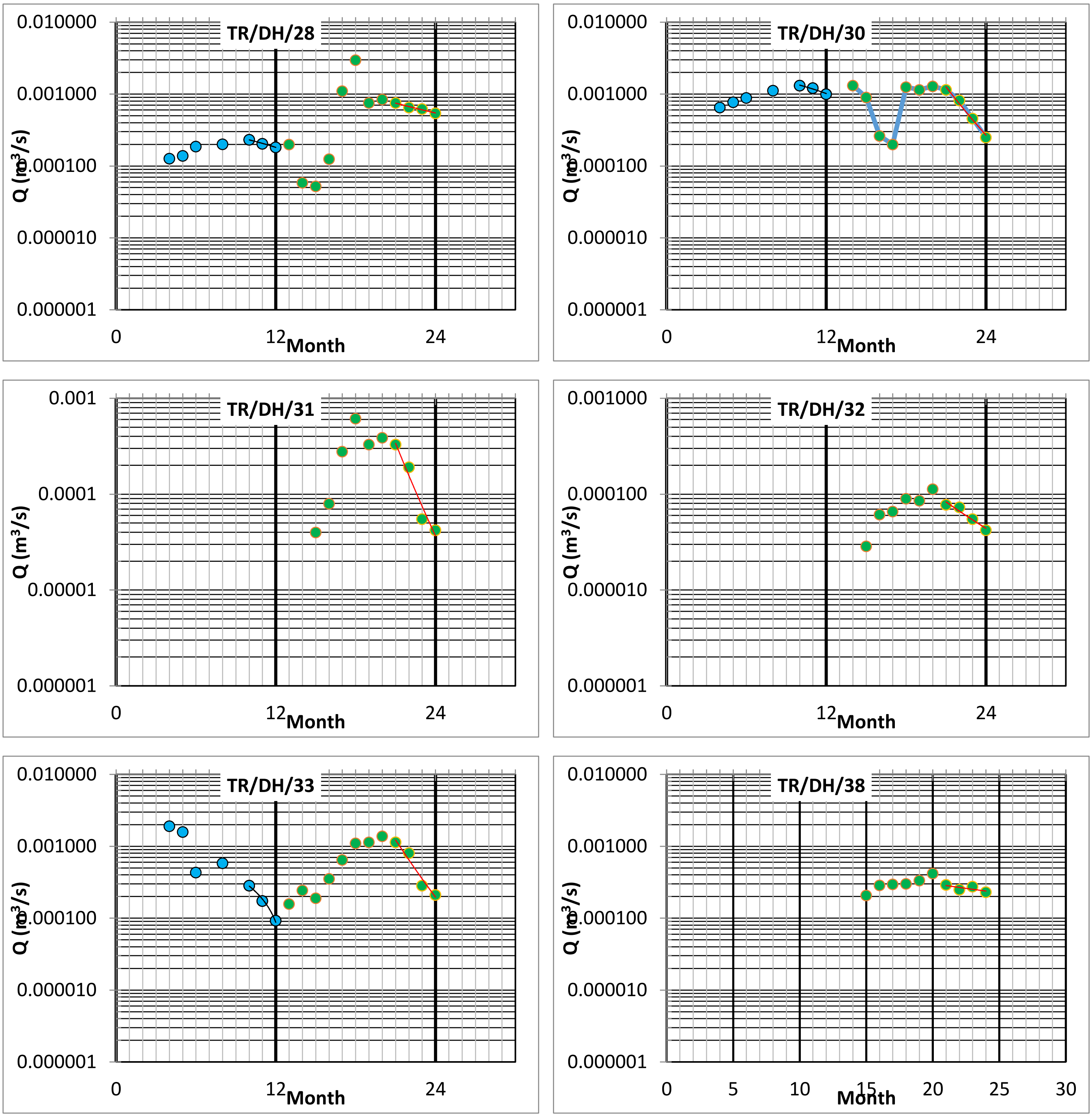


Figure 4-4: Recession hydrograph of springs of Kamalpur Valley, Dhalai Disrict, Tripura.

Table 4:6: Discharge (m^3/s) data of Kamalpur Valley, Dhalai district, Tripura

S.No	Spring ID	TR/DH/19	TR/DH/31	TR/DH/32	TR/DH/17	TR/DH/07	TR/DH/13	TR/DH/20	TR/DH/06	TR/DH/30	TR/DH/02	TR/DH/26	TR/DH/27	TR/DH/01
1.	**Apr-23**	0.0253			0.0130	0.0290	0.9615	0.0511	0.0769	0.6536	0.0179	0.0029	0.0090	0.1073
2.	**May-23**	0.0306			0.0152	0.0350	1.1111	0.0606	0.0909	0.7752	0.0226	0.0031	0.0101	0.1138
3.	**Jun-23**	0.0353			0.0191	0.0468	1.2500	0.0792	0.1250	0.8881	0.0300	0.0039	0.0120	0.1383
4.	**Jul-23**	0.0460				0.0430								
5.	**Aug-23**	0.0411			0.0216	0.0511	1.5480	0.1036	0.1531	1.1161	0.0350	0.0044	0.0131	0.1504
6.	**Sep-23**	0.0480				0.0530								
7.	**Oct-23**	0.0420			0.0214	0.0546	2.1645	0.1040	0.1414	1.3158	0.0459	0.0044	0.0138	0.2193
8.	**Nov-23**	0.0378			0.0195	0.0460	1.6779	0.0873	0.1202	1.2136	0.0402	0.0042	0.0127	0.1953
9.	**Dec-23**	0.0345			0.0171	0.0373	1.4451	0.0698	0.1012	0.9980	0.0336	0.0039	0.0116	0.1475
10.	**Jan-24**	0.0171			0.0224	0.0520	1.4451	0.1370	0.2488	1.1111	0.0478	0.0050	0.0167	0.0952
11.	**Feb-24**	0.0153			0.0263	0.0491	0.6878	0.0616	0.2927	1.3158	0.0399	0.0100	0.0217	0.0221
12.	**Mar-24**	0.0102	0.0397	0.0286	0.0351	0.0406	0.6460	0.0630	0.1142	0.8993	0.0402	0.0156	0.0212	0.0562
13.	**Apr-24**	0.0278	0.0791	0.0610	0.0179	0.0800	0.6150	0.0625	0.1597	0.2630	0.0455	0.0089	0.0250	0.1695
14.	**May-24**	0.0744	0.2773	0.0658	0.0321	0.2450	0.9225	0.3546	0.1547	0.2000	0.0641			0.7622
15.	**Jun-24**	0.1266	0.6136	0.0896	0.0611	0.5790	4.9020	0.8292	0.4149	1.2523	0.1151			2.7027
16.	**Jul-24**	0.0596	0.3280	0.0852	0.0607	0.5342	5.8824	0.4000	0.5669	1.1510	0.1661			3.5714
17.	**Aug-24**	0.0690	0.3864	0.1124	0.0643	0.6450	7.5758	0.4739	0.6427	1.2800	0.1953			4.4248
18.	**Sep-24**	0.0508	0.3280	0.0775	0.0431	0.3870	3.1250	0.3125	0.4950	1.1510	0.1404	0.0259	0.0162	2.6455
19.	**Oct-24**	0.0223	0.000190	0.000073		0.000168	0.002600	0.000270	0.000390	0.000820	0.000120		0.000017	0.002200
20.	**Nov-24**	0.0195	0.0549	0.0549	0.0267	0.1400	1.5723	0.2193	0.3837	0.4580	0.0805	0.0149	0.0124	2.0408
21	**Dec-24**	0.0140	0.0570	0.0420	0.000025	0.000110	0.001400	0.000180	0.000280	0.000250	0.000067		0.000011	0.001500

S.No.	Spring ID	TR/DH/28	TR/DH/08	TR/DH/09	TR/DH/14	TR/DH/10	TR/DH/18	TR/DH/03	TR/DH/15	TR/DH/33	TR/DH/16	TR/DH/38
1.	Apr-23	0.1266	0.0952	0.0057	0.0116	0.0057	0.0031	0.0105	0.0138	1.9011	0.0131	
2.	May-23	0.1389	0.1250	0.0064	0.0132	0.0064	0.0035	0.0114	0.0152	1.58619	0.0162	
3.	Jun-23	0.1876	0.1667	0.0081	0.0155	0.0075	0.0042	0.0137	0.0206	0.43	0.0216	
4.	Jul-23											
5.	Aug-23	0.2008	0.1883	0.0089	0.0176	0.0084	0.0048	0.0146	0.0236	0.5803	0.0253	
6.	Sep-23											
7.	Oct-23	0.2315	0.2232	0.0110	0.0168	0.0088	0.0066	0.0174	0.0236	0.28432	0.0309	
8.	Nov-23	0.2045	0.1745	0.0101	0.0149	0.0084	0.0057	0.0153	0.0202	0.1728	0.0253	
9.	Dec-23	0.1821	0.1536	0.0089	0.0134	0.0073	0.0051	0.0137	0.0163	0.09268	0.0206	
10.	Jan-24	0.1992	0.1502	0.0129	0.0175	0.0080	0.0079	0.0474	0.0197	0.157	0.0225	
11.	Feb-24	0.0584	0.2744	0.0088	0.0160	0.0044	0.0061	0.0351	0.0233	0.243	0.0160	
12.	Mar-24	0.0523	0.0940	0.0084	0.0138	0.0043	0.0082	0.0336	0.0196	0.18916	0.0252	0.2072
13.	Apr-24	0.1250	0.0800	0.0047	0.0106	0.0040	0.0500	0.0333	0.0145	0.352	0.0209	0.2857
14.	May-24	1.1000	0.5000	0.0041	0.0400		1.5576	0.1409	0.1850	0.647	0.0416	0.2959
15.	Jun-24	2.9706	0.7032	0.1401	0.0680	0.0427	0.1059	0.0403	0.1970	1.102	0.0263	0.2989
16.	Jul-24	0.7570	0.6849	0.0448	0.0430	0.0401	0.1153	0.2078	0.2240	1.1358	0.0274	0.3322
17.	Aug-24	0.8435	0.7576	0.0523	0.0370	0.0495	0.1285	0.2634	0.2870	1.376	0.0317	0.4174
18.	Sep-24	0.7570	0.5814	0.0354	0.0370	0.0317	0.0988	0.1603	0.2240	1.1358	0.0230	0.2895
19.	Oct-24	0.000650	0.000350	0.000030	0.000032	0.000028	0.000080	0.000130	0.000180	0.000800	0.000020	0.000250
20.	Nov-24	0.6230	0.2843	0.0216	0.0287	0.0189	0.0548	0.0912	0.1040	0.2843	0.1728	0.2749
21.	Dec-24	0.000540	0.000200	0.000018	0.000020	0.000017	0.000043	0.000075	0.000080	0.000210	0.000015	0.000230

5. GEOPHYSICAL STUDIES

5.1. INTRODUCTION:

Groundwater plays a crucial role in meeting both rural and urban water demands in the state of Tripura. Due to the region's complex hydrogeological conditions and the rising pressure of groundwater extraction, there is a growing need for a systematic and scientific approach to the development, management, protection, and conservation of groundwater resources.

Effective groundwater management requires a multidisciplinary approach, with geophysics being one of the key components. During the Annual Action Plan (AAP) of 2023–24, a total of 21 Vertical Electrical Soundings (VES) were conducted in and around the Dhalai District to assess subsurface groundwater potential.

The Electrical Resistivity Method was employed to identify optimal sites for exploratory drilling in soft rock formations and to assist in locating spring sheds. Since groundwater conditions in soft rock regions are highly variable, it is essential to adopt appropriate geophysical techniques tailored to specific geological settings. Geophysical surveys are an integral part of groundwater exploration, significantly increasing the success rate of locating productive aquifers.

In Dhalai District, the geophysical team made a substantial contribution to groundwater development and resource management. The collected resistivity data was systematically analyzed and compiled into technical reports for further interpretation and planning. The analysis of resistivity data obtained from VES provides detailed insights into subsurface lithology. This includes identifying layers such as topsoil, clay, sandy clay, clayey sand, boulders, hard rock, and sand formations. Over time, the interpretation of resistivity data has become more accurate and reliable.

5.2. METHODOLOGY:

Up until the late 1980s, interpretation techniques such as standard master curves by Orellana and Mooney, and auxiliary curve methods were commonly used. However, in the last four decades, advances in computer modeling—particularly forward and inverse modeling techniques—have significantly improved the accuracy of interpretation. These methods have addressed previous ambiguities, especially those related to the Principle of Equivalence, and allow for more refined analysis through iterative adjustments when lithology is known. The interpreted data yields resistivity and thickness values that are used to develop geoelectric models correlating with specific subsurface materials like clay, sand, and boulders.

Electrical Resistivity Method is one of the most common geophysical investigation techniques due to its easy and convenient method of operation as well as having diversified applications in geophysical domain. It is also superior to other electrical methods theoretically because quantitative results are obtained by using a controlled source of specific dimensions. The method includes injecting into the ground with the help of two current electrodes and then measurement of potential difference at a point between two potential electrodes. Due to inhomogeneous nature of the ground, the current flow as well as distribution of electric potential also becomes in homogeneous. Hence measured electric voltage between two points of surface depends on the subsurface environment of these points, that is, variations in measured voltage bear effects of the site lithology.

5.2.1. Principle:

Ohm's law: Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points.

$$\boxed{i = \frac{1}{R} V}$$

Where **R**= Resistance of the material, **V**= Potential applied, **I**=Current flowing. This is known as the Ohm's Law. Its unit is Ohm (Ω). Resistance depends upon the length and area of cross section of the conductor.

Resistivity is the resistance of a material of unit length and unit cross-sectional area.

The resistivity (ρ) of material is represented by:

$$\rho = R\, l / a$$

Where **l** – length of the conductor (m), **a** – cross-section area of conductor (m2) **R** – Resistance of the material (Ω). Thus, the unit of Resistivity is Ohm m, since it represents resistance of unit length.

5.2.2. Electrode Configurations:

Electrode configurations or arrays are of different types which gives different depth of penetration and resolution and has different resistivity formulae due to the difference in geometric factor. In practical application the current electrodes are denoted by A and B and the potential electrodes are denoted by M and N. The types of configurations are:

i) **Wenner Array:** In this array, the electrodes are placed at equal distance and the potential electrodes are placed between current electrodes and it is a common array. The line segment MN is equal to one third of the line segment AB (MN=AB/3).

ii) **Schlumberger Array:** The midpoint of the space between potential electrodes is identical with the midpoint of the space between current electrodes. The separation of current electrodes or AB/2 is 5 times the separation between the potential electrodes or MN/2.

iii) Dipole-Dipole Array: It is a type of unsymmetrical array since the potential electrodes are planted outside the current electrodes and there is no common midpoint. Space between current electrodes AB and potential electrodes MN are equal. The distance between the midpoints of AB and MN is very large compared to electrode spacing. The electrodes behave like a pair of dipoles.

iv) Pole-Dipole Array: In pole-dipole array one of the current electrodes fixed at a great distance from other three electrodes and all of which have various distance and second current electrode is need not necessary to have it in line with other three. This is permits to lateral exploration on radial lines from a fixed position of first current electrode.

5.2.3. VES (Vertical Electrical Sounding)

VES has been carried out in the study area using Schlumberger Array. It is used to determine the vertical variations in resistivity below a point on the ground surface. Its application is to find the number of layers in the subsurface, depth range of rock layers in the subsurface layers and find zones of low resistivity, zones of faults, clay layers or weathered zones. The most commonly used electrode configuration is the Schlumberger array since the potential electrode placement are constant for most of the length and changed only to the corresponding readings to maintain the AB/2 = 5MN ratio. The distance between the current electrodes is increased after the measurement of an apparent resistivity has been taken. By this step wise increase of current electrode spacing, the current is able to penetrate into deeper and deeper parts of the subsurface.

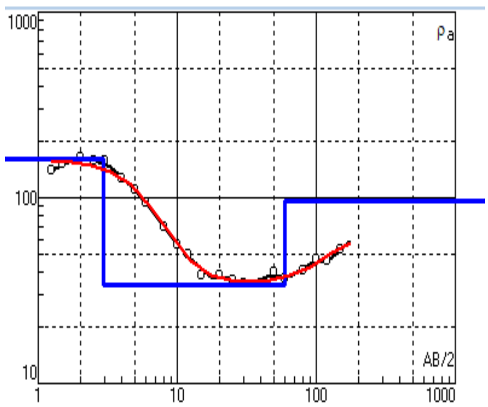


Figure 5-1: An example of Log-Log Plot of the Apparent Resistivity vs AB/2 (Distance of the electrode)

It is represented by a log-log plot. The horizontal axis of an apparent resistivity plot is logarithmically scaled by the half of the current electrode spacing (AB/2), and the vertical axis is logarithmically scaled by the apparent resistivity.

The final outcome would be the calculation of the resistivity of the subsurface ground layers. The main principle is that different rock formations have different varying conductivities or resistivities and deviations from the pattern of potential differences expected from homogeneous ground (ideal condition where subsurface has only one layer of homogeneous rock type distribution) provide information on the form and electrical properties of subsurface in-homogeneities.

5.2.4 The Instruments used:

SSR-MP-ATS is a cutting-edge microprocessor-based data acquisition system that incorporates several innovative features and advanced digital circuitry techniques. It is a reliable geophysical tool that provides high-quality data useful for mineral and groundwater exploration, as well as other geophysical applications.

The SSR-MP-ATS sends the entire current into the ground without wasting power for constant current generation, increasing the signal strength to probe deeper layers. The advanced design of the SSR-MP-ATS Resistivity Meter achieves excellent depth penetration with relatively low power inputs. It utilizes signal stacking up to 16 successive readings to achieve good signal enhancement.

In the presence of random (non-coherent) earth noises, the signal to noise ratio of the SSR-MP-ATS measurement is enhanced by N, where N is the number of stacks. Therefore, the SSR-MP-ATS Resistivity Meter can be used for depths of up to 600m under favourable geological field conditions.

Applications of SSR-MP-ATS include groundwater exploration, bedrock investigations, delineation of geological structures, identification of sand and gravel deposits, and mineral investigations.

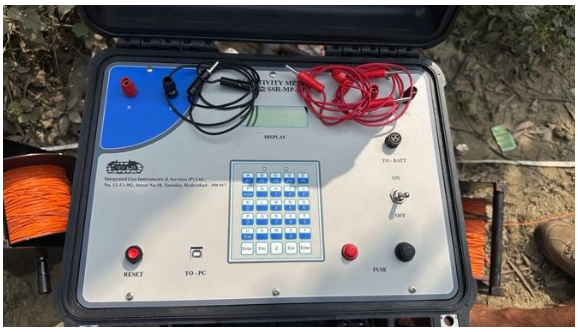


Figure 5-2: SSR MP ATS Instrument used for VES Survey in the Study Area

Figure 5-3: Field Photograph from Iladhan Site, Dist. Dhalai, Tripura

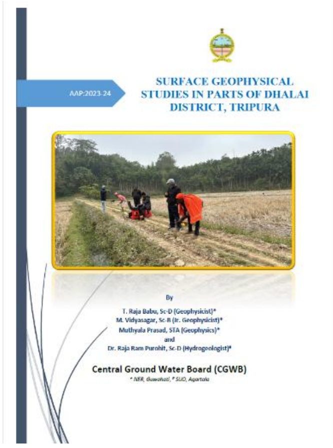


Figure 5-4: The report submitted on geophysical study in Dhalai Dist Tripura

5.3. GEOPHYSICAL STUDIES RESULTS AND INTERPRETATIONS

In the study area of Dhalai, there were challenges due to a large number of buildings, constructions, and hilly terrain. This resulted in limited space for resistivity surveys in some areas, and the current electrode spread available was between 50 m and 1000 m. The team could obtain VES curves of Q, QH, HKH, HK, HKHK, KQ, and KHA types. The team have interpreted the results of the VES and made inferences concerning possible sub-surface geology. The area being in the soft rock formation with loose sediments, it was not feasible to exactly determine the Water Level, however, few water bearing formation could be deduced.

The detailed Locations and stretches are given in the Map below as well as tabulated in the **Annexures (11.10).**

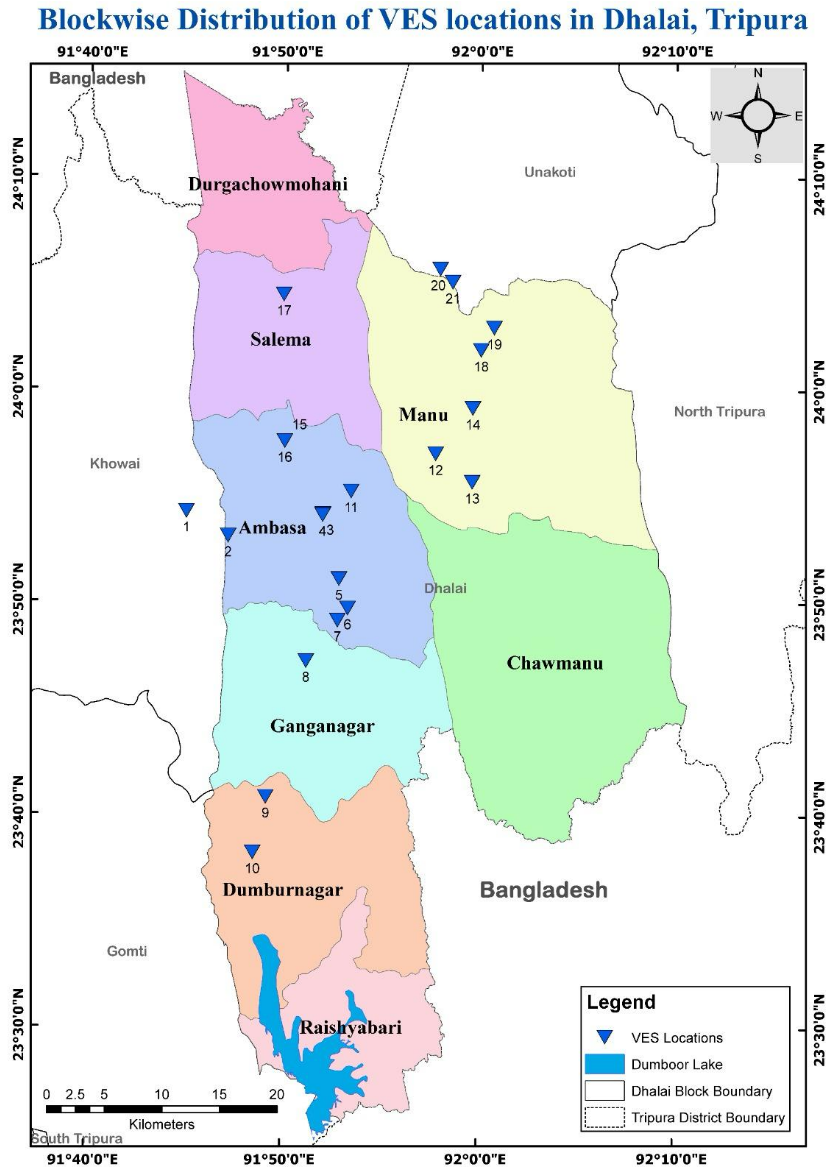


Figure 5-5: The location of the VES Survey conducted in Dist. Dhalai, Tripura. The details are given in the ***Annexure 11.10.***

The detailed report on all the 21 VES studies along with their data and interpretation are already published and available online at CGWB's publication wearhouse.

Some of the selected sites and their Graphical plots along with their interpreted results are given as follows:

5.3.1. VES - 3: Iladhan-1

District: DHALAI, Village: ILADHAN, TRIPURA
(Latitude: 23.9023716, Longitude: 91.8665523)
AB/2: 200 m

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L. - 0.49	0.49	152.9	Top soil with dry shale
0.49 - 1.35	0.85	20.61	Clay
1.35 - 3.36	2.01	211	Sand with dry shale
3.36 -8.97	5.60	8.7	Sandy clay
8.97 - 15.98	7.04	94.24	Sand
>15.98		17.49	Clay

The Inferred zone of Water bearing formation is from 2 to 16 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

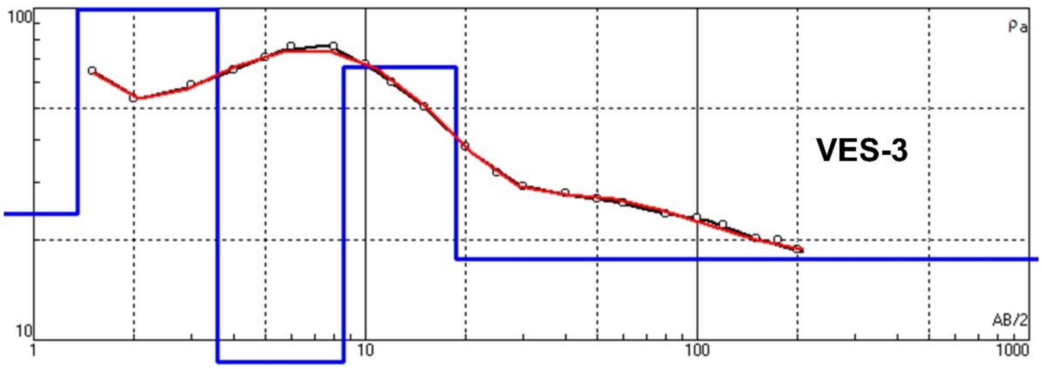


Figure 5-6: VES Plot of AB/2 vs Apparent Resistivity of Iladhan-1, Dist. Dhalai, Tripura

5.3.2. VES - 4: Iladhan-2 (T)

District: DHALAI, Village: ILADHAN, TRIPURA
(Latitude: 23.901508, Longitude: 91.8662804)
AB/2: 80 m
Note: Transverse to Iladhan-1

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L. - 0.9	0.9	62.5	Top soil with dry Shale
0.9 - 1.92	1.02	20.2	Clay
1.92 - 8.77	6.85	110	Sand with clay (Dry Shale)
>8.77		22.7	Sandy Clay

The Inferred zone of Water bearing formation is from 2 to 16 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

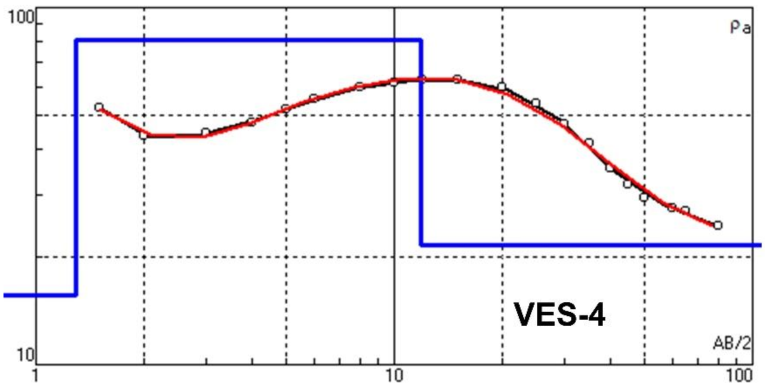


Figure 5-7: VES Plot of AB/2 vs Apparent Resistivity of Iladhan-2 (T), Dist. Dhalai, Tripura

5.3.3. VES - 15: Basudevpur-1

District: DHALAI, Village: BASUDEVPUR, TRIPURA
(Latitude: 23.959271, Longitude: 91.833507)
AB/2: 500 m

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L - 0.9	0.9	38	Top soil with clay
0.9 - 3.7	2.8	21	Clay

3.7 - 15.2	11.5	105.2	Sand formation
15.2 - 52.4	37.2	57	Sandy clay
52.4 - 120.9	68.5	127.2	Sand formation
>120.9		55	Sandy clay

The Inferred zone of Water bearing formation is from 3 to 31 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

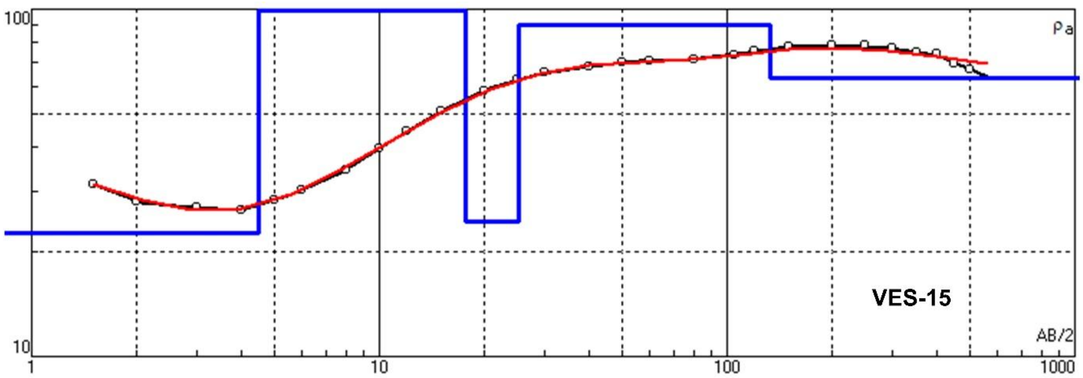


Figure 5-8: VES Plot of AB/2 vs Apparent Resistivity of Basudevpur-1, Dist. Dhalai, Tripura

5.3.4. VES - 16: Basudevpur-2 (T)

District: DHALAI, Village: BASUDEVPUR, TRIPURA
(Latitude: 23.959271, Longitude: 91.833507)
AB/2: 400 m
Note: Transverse to Basudevpur-1

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L - 0.71	0.74	40.64	Top soil
0.71 - 4.3	3.58	24.97	Clay
4.3 - 31.4	27.1	85.4	Clayey sand
31.4 - 45	13.6	37.23	Sandy clay
45 - 105.9	60.95	134.9	Sand formation
>105.9		60.62	Clayey fine sand

The Inferred zone of Water bearing formation is from 3 to 31 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

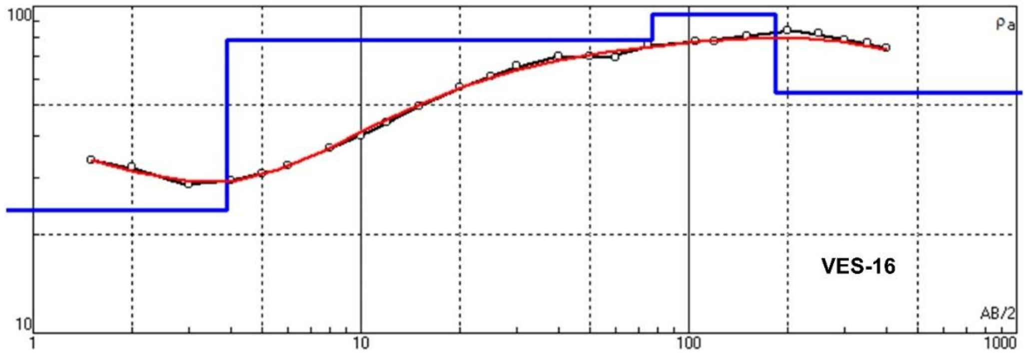


Figure 5-9: VES Plot of AB/2 vs Apparent Resistivity of Basudevpur-2 (T), Dist. Dhalai, Tripura

5.3.5. VES - 17: Abhanga

District: DHALAI, Village: ABHANGA, TRIPURA
(Latitude: 24.074127, Longitude: 91.831818)
AB/2: 398 m

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L - 0.43	0.43	163	Top soil
0.43 - 4.14	3.7	35.2	Sandy clay
4.14 - 10	5.86	138	Sand formation
10 - 78.6	68.6	27.8	Clay with fine sand
>78.6		47.7	Clayey sand

The Inferred zone of Water bearing formation is from 4 to 10 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

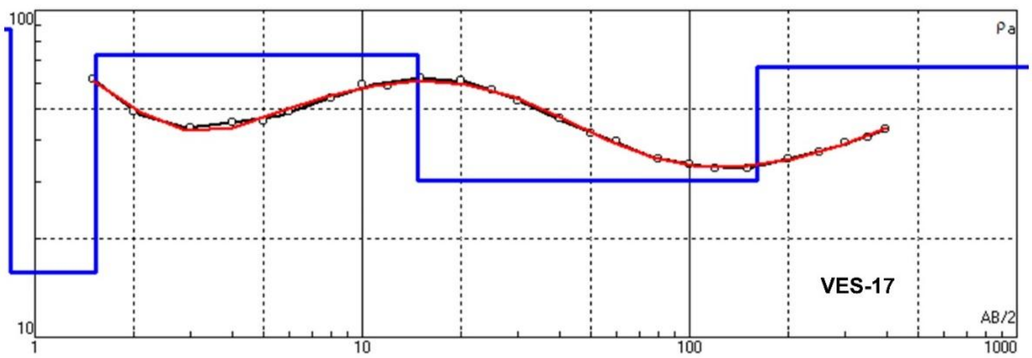


Figure 5-10: VES Plot of AB/2 vs Apparent Resistivity of Abhanga, Dist. Dhalai, Tripura

5.3.6. VES - 21: Musonli

District: DHALAI, Village: MUSONLI, TRIPURA
(Latitude: 24.0843585, Longitude: 91.9759683)
AB/2: 300 m

The Inferred lithological data are tabulated below.

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L - 0.78	0.78	66.03	Top soil
0.78 - 12.82	12.03	33.89	Sandy clay
12.82 - 24.69	11.87	161.5	Sand formation
24.69 - 51.13	26.44	55.95	Clayey sand
>51.13		48.64	Medium sand with clay

The Inferred zone of Water bearing formation is from 12 to 24 m below the ground surface (m bgl).

The Graphical plot of the inferred data is presented below:

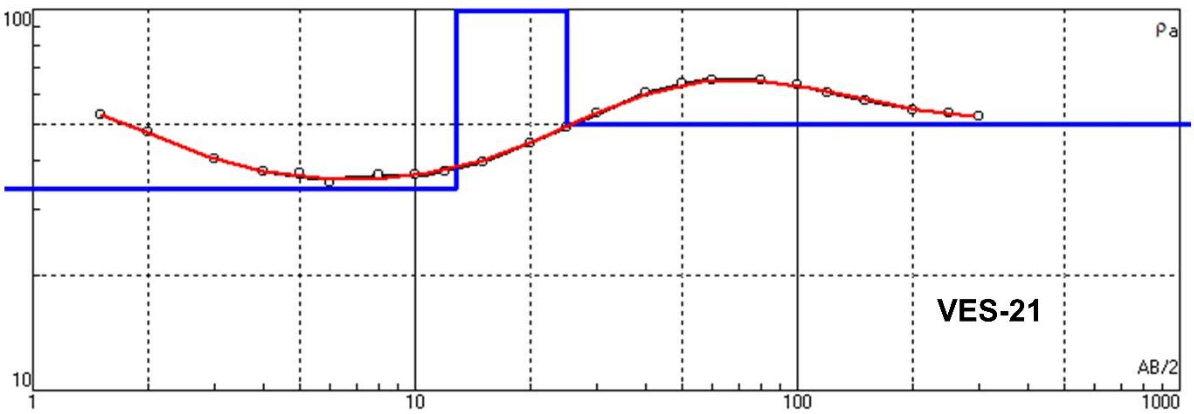


Figure 5-11: VES Plot of AB/2 vs Apparent Resistivity of Musonli, Dist. Dhalai, Tripura

5.3.7. Geological Classification of VES Sites

- **VES-1 to VES-8, VES-11, VES-16, and VES-17** are located within the *Unconsolidated Tipam Sandstone* geological formation.
- **VES-12 to VES-15 and VES-18 to VES-21** fall within regions containing both *Unconsolidated Tipam Sandstone* and *Recent Alluvium*.
- **VES-9 and VES-10** are associated with the *Semi-Consolidated Bokabil Formation*.

5.3.8. Subsurface Lithology and Groundwater Potential

From the geophysical survey data, the following subsurface characteristics were inferred:

- **Topsoil/Topsoil with clay**: Thickness varies from 0.5 to 2 meters, with depth reaching up to 2 meters below the surface.
- **Topsoil with boulders**: Found in selected areas, ranging from 0.8 meters to a depth of 5.3 meters.
- **Clay formation**: Lies beneath the topsoil and varies significantly in thickness (0.8 to 58 meters) and depth (0.4 to 105 meters).
- **Sand with shale**: Has a typical thickness of around 2 meters, at depths between 1 and 3 meters.
- **Sandy clay**: Thickness ranges from 3 to 94 meters, with depths from 0.8 to 120 meters.
- **Sand layer**: Thickness ranges from 0.4 to 68.5 meters, with corresponding depths between 0.8 and 120 meters.
- **Sand with clay**: Found at depths ranging from 1.9 to 8.7 meters, with a thickness of about 6.8 meters.
- **Shale layer**: Typically occurs at an approximate depth of 8 meters.
- **Clayey sand**: This is the most dominant subsurface layer, with thickness varying from 0.5 to 98 meters and depth from 2 to 102 meters.
- **Tipam Sandstone/Hard Rock**: Interpreted at depths ranging from 12 to 102 meters.

The approximate groundwater potential zones identified through this study are between 1 meter and 100 meters deep, highlighting significant opportunities for groundwater development in the study area.

5.4. INTERESTING FINDING/CASE STUDY

5.4.1. A: Harincherra (Hirankudna)

- Spring Location ID: TR/DH/06, Hirankudna Spring
- VES ID: 5, Harincherra
- Type: Single/Multiple Array of Springs
- Discharge: 1 LPS Total (Outlet One: 0.3 LPS, Outlet Two: 0.25 LPS, Outlet Three: 0.20 LPS, plus many small Outlets
- Preliminary Inference of Spring Type: Contact Spring
- Height Difference between Survey Point and the Spring Outlet: 5.25 mtrs below Survey Level

The Site Photographs:

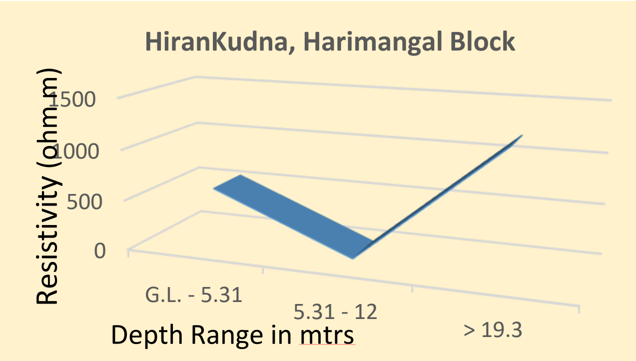
Figure 5-12: Site photographs of Hirankudna Spring (i: Survey Site, ii: Height difference between the survey point and the Spring, iii: the Spring line)

VES Interpretation:

- **VES ID: 5, Harincherra, Spread: 50 mtr (AB/2=25 mtr)**

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Probable lithology
G.L. - 5.31	5.31	578	Top soil with boulders
5.31 - 12	**6.74**	**19**	**Clay**
> 19.3		1205	Sand with hard formation/ hard rock

Graphical Plot:



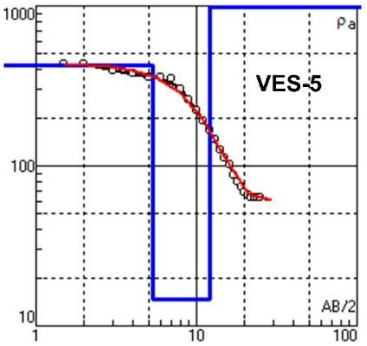


Figure 5-13: Graphical Plot of Apparent Resistivity at Hirankudna Spring site.

Inference:

The Geophysical survey exactly delineate the presence of impervious clay bed under the pervious to semipervious layer, inhibiting the downward flow of water, where in the ground water comes out to the surface in the for of spring, thereby confirming the spring type of Contact type spring.

5.4.2. B: Kathalbari

- Spring Location ID: Khathalbari, Ambassa Block
- VES ID: 11, Kathalbari
- Type: Single/Multiple Array of Springs
- Discharge: Total Not measurable (too numerous to count), Outlet One: 0.2 LPS, Outlet Two: 0.175 LPS, Outlet Three: 0.23 LPS plus many more Outlets
- Preliminary Inference of Spring Type: Contact Spring
- Height Difference between Survey Point and the Spring Outlet: 4.75 mtrs below Survey Level

The Site Photographs:

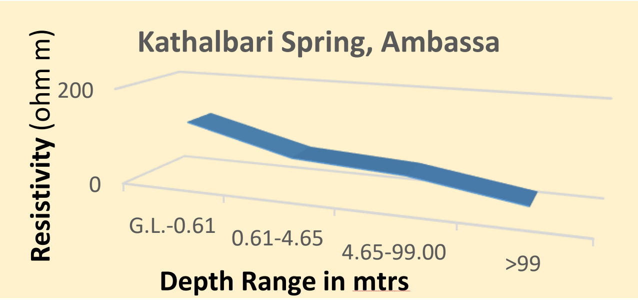
Figure 5-14: Site photographs of Kathalbari Spring (i: Survey Site, ii: Height difference between the survey point and the Spring, iii: the Spring line.)

VES Interpretation:

- **VES ID: 11, Kathalbari, Spread: 200 mtr (AB/2=100mtr)**

Depth range(m)	Thickness	Interpreted layer resistivity (ohm.m)	Probable lithology
G.L. - 0.61	0.61	125	Top soil with clay
0.61 - 4.65	4.04	69.18	Clayey sand
4.65 - 99.00	**94.35**	**56.44**	**Sandy clay**
> 99		21.52	Clay formation

Graphical Plot:



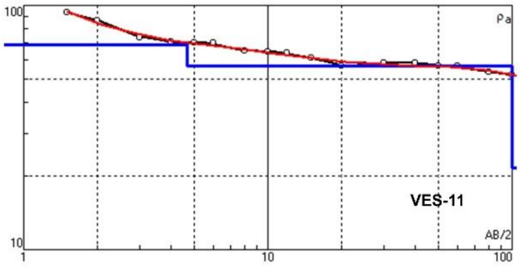


Figure 5-15: Graphical Plot of Apparent Resistivity at Kathalbari Spring site.

Inference:

The Geophysical survey exactly delineate the presence of impervious clay bed under the pervious to semipervious layer, inhibiting the downward flow of water, where in the ground water comes out to the surface in the form of spring, thereby confirming the spring type of Contact type spring.

5.5. CONCLUSION OF THE GEOPHYSICAL STUDY:

Due to the limited availability of a large and straight stretch for current electrode separation (Maximum separation obtained was 1 km), it was not possible to obtain inferences for deeper formations based on the interpreted results. However, taking into account the apparent resistivities and interpreted results, approximations have been made for both shallow and deeper depths in a few areas. The results indicate the potential for groundwater development from both shallow and deeper aquifers.

The geophysical survey has supported the NAQUIM 2.0 study in deciphering the type of springs be identification of impermeable zone underlying, where otherwise world have been an approximation.

6. ASSESSMENT OF SPRING WATER QUALITY

6.1. INTRODUCTION:

The quality of spring water is governed by a complex interplay of hydrogeological processes, geochemical interactions, and anthropogenic influences, from precipitation infiltration to groundwater discharge at natural spring outlets. As water percolates through geological formations, it undergoes mineral dissolution, ion exchange, and microbial activity, which collectively shape its chemical composition and usability. Various factors—including local geology, climatic conditions, land-use patterns, and human activities such as agriculture, deforestation, and industrial discharge—significantly impact spring water quality, causing notable variations across different hydrogeological settings.

Spring water quality assessment is essential for determining its suitability for drinking, irrigation, livestock, and industrial applications. Hydrogeochemical investigations establish the water quality criteria, which provide scientific benchmarks for acceptable physicochemical characteristics based on the intended use. Water quality standards, on the other hand, are regulatory frameworks set by national or international authorities, enforcing limits on contaminants to ensure safe water utilization. These standards integrate criteria-based recommendations, designated water uses, enforcement mechanisms, and monitoring protocols to maintain long-term water sustainability.

Several studies emphasize the importance of hydrogeochemical parameters in assessing spring water suitability. For drinking purposes, parameters such as pH, total dissolved solids (TDS), hardness, fluoride, arsenic, and microbial contaminants are critical in determining potability. Springs with low TDS and balanced ionic composition often provide freshwater resources, whereas excessive mineralization, microbial pollution, or anthropogenic contaminants can necessitate water treatment. In irrigation applications, assessments focus on sodium adsorption ratio (SAR), residual sodium carbonate (RSC), electrical conductivity (EC), and chloride concentration, as high salinity and sodium levels can negatively impact soil permeability and crop productivity. Similarly, industrial standards consider heavy metal presence, alkalinity, and organic load, as certain contaminants can interfere with manufacturing processes and environmental sustainability. Studies such as those by Sayers et al. (1976, as cited in CGWB & CPCB 2000), Wilcox (1955), and Piper (1944) have played foundational roles in developing classification systems and analytical methodologies for assessing spring water quality across different climatic and geological contexts.

6.2. ASSESSMENT FOR DRINKING PURPOSE BASED ON BIS LIMITS FOR THE BASIC PARAMETERS

To safeguard water from degradation and establish a foundation for improving water quality, various national and international organizations have developed standards, guidelines, and regulations. These include the Bureau of Indian Standards (BIS), the World Health Organization (WHO), the European Economic Community (EEC), the Environmental Protection Agency (EPA) of the United States, and the Inland Waters Directorate of Canada. The Bureau of Indian Standards (BIS), formerly known as the Indian Standards Institution (ISI), first established drinking water standards in 1983, which have been periodically revised and updated. To aid users in making informed decisions regarding water quality, the BIS has prescribed maximum permissible limits, particularly in situations where alternative water sources are unavailable.

During monsoon 2023, the overall water quality was largely favourable for drinking, with most samples falling within BIS-defined limits. pH values (6.94–8.31) were well within acceptable ranges, ensuring water remained neither excessively acidic nor alkaline. Turbidity was below detection limits in most samples, except for a few locations where recorded values exceeded 1 NTU, indicating the presence of suspended particles. TDS concentrations (41.73–497.60 mg/L) remained within the desirable limit of 500 mg/L, confirming moderate mineralization without excessive salinity concerns. Chloride (7.09–215.20 mg/L) and sulfate (0.59–149.46 mg/L) values stayed within recommended thresholds. Nitrate levels (0.01–34.03 mg/L) did not exceed the permissible limit of 45 mg/L, ensuring safety against contamination risks such as agricultural runoff. However, fluoride concentrations (0.01–1.25 mg/L) exceeded 1 mg/L in some samples, requiring monitoring to prevent potential health effects such as dental fluorosis. The post-monsoon 2023 period exhibited slightly higher mineralization compared to monsoon conditions, likely due to reduced recharge rates and prolonged groundwater residence time. While pH values remained stable (6.76–8.31), turbidity was still low, ensuring visual clarity. TDS concentrations (37.53–628.06 mg/L) showed an increase, with some locations exceeding 500 mg/L, highlighting progressive salt accumulation and dissolved ion concentrations. The presence of chloride (7.09–215.20 mg/L), sulphate (0.59–149.46 mg/L), and nitrate (0.01–34.03 mg/L) remained within safe limits. However, fluoride concentrations continued to show slight exceedances beyond 1 mg/L in isolated locations, reinforcing the need for localized mitigation strategies. The pre-monsoon 2024 data reflected further increases in mineralization, a common phenomenon due to limited recharge, increased evaporation, and enhanced ion exchange reactions in dry seasons. pH values (6.82–8.41) remained within safe ranges, ensuring drinkability. Turbidity remained below detection limits in most samples, confirming low particle presence. However, TDS values (41.73–679.20 mg/L) exhibited a rise, with more samples exceeding 500 mg/L, necessitating attention to potential salinity-related health risks. While chloride, sulphate, and nitrate concentrations remained within BIS-defined limits, fluoride continued to exhibit periodic exceedances beyond 1 mg/L, requiring fluoride filtration measures in affected springs. A comparative analysis across the three seasons suggests that monsoon-season spring water is the most favourable for drinking, whereas post-monsoon and pre-monsoon seasons display progressive mineralization trends, necessitating monitoring and localized interventions.

6.3. SUITABILITY OF SPRING WATER FOR DRINKING PURPOSES BASED ON BIS LIMITS FOR IRON (Fe) AND MANGANESE (Mn)

Groundwater quality is influenced by geochemical processes, seasonal variability, and anthropogenic activities, affecting the concentrations of various metals and trace elements. In the springs of Dhalai district, Tripura, multiple metals—including Al, Cr, Cd, Cu, Zn, Pb, Hg, and U—were analyzed, but only Iron (Fe) and Manganese (Mn) exceeded BIS limits.

Iron is an essential nutrient but poses aesthetic and infrastructural concerns when present above 1 mg/L, the BIS limit for drinking water. Excess Fe concentrations can lead to reddish-brown discoloration, metallic taste, and staining of household surfaces and plumbing. Additionally, high Fe levels may contribute to biofilm formation in water distribution systems, reducing water quality. While iron toxicity is rare, excessive intake may interfere with nutrient absorption, requiring filtration or oxidation methods to maintain potable water standards. Manganese, with a BIS limit of 0.3 mg/L, is also an essential trace element, but its overabundance can cause blackish staining, undesirable taste, and neurological concerns with prolonged exposure. Elevated Mn concentrations may also promote bacterial growth, affecting the quality of drinking water. Unlike Fe, manganese toxicity can lead to neurological disorders, reinforcing the necessity of proper water treatment when levels exceed recommended thresholds.

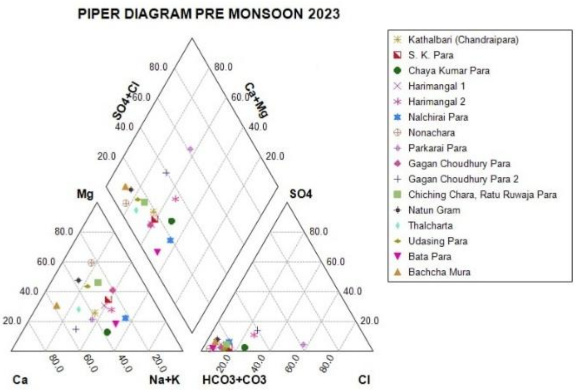
The analysis of monsoon 2023 water samples revealed Fe concentrations ranging from BDL (Below Detection Limit) to 6.075 mg/L, with Kathalbari-1 (Chandraipara) showing the highest levels. Springs like Gagan Choudhury Para 2 and Chiching Chara exceeded the BIS limit, suggesting iron enrichment due to prolonged rock-water interaction. Similarly, Mn levels varied from BDL to 1.921 mg/L, exceeding limits in NatunGram, Nonachara, and Parkarai Para, necessitating intervention measures such as filtration and aeration. During post-monsoon 2023, Fe concentrations declined slightly, with most springs recording BDL to 1.544 mg/L. This seasonal variation suggests dilution effects due to monsoonal recharge, resulting in lower Fe accumulation. However, Mn levels remained elevated in certain springs, peaking at 0.824 mg/L in Natungram, indicating persistent mineral dissolution despite seasonal changes. The pre-monsoon 2024 analysis showed continued Fe presence in some springs, with 45 Miles Springs (NH-8) recording 0.45 mg/L. Manganese concentrations remained relatively high, suggesting reduced groundwater recharge leading to increased metal dissolution. The persistence of Mn exceedances beyond BIS limits reinforces the need for periodic monitoring and site-specific water treatment strategies.

6.4. PIPER PLOT

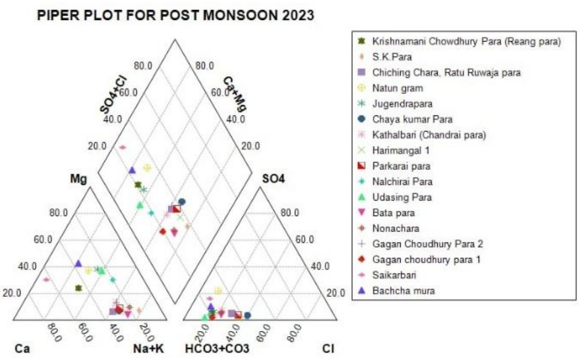
The hydrochemical analysis of spring water in Dhalai district, Tripura, across monsoon 2023, post-monsoon 2023, and pre-monsoon 2024 seasons reveals distinct seasonal variations in groundwater composition. The Piper plot interpretations illustrate progressive shifts in ionic dominance driven by recharge cycles, evaporation effects, and mineral interactions.

During the monsoon season of 2023, the Piper plot predominantly reflects a calcium-magnesium-bicarbonate (Ca-Mg-HCO_3) water type. This classification indicates active recharge due to monsoon precipitation, maintaining the freshness of spring water with minimal ion exchange. The abundance of calcium and bicarbonate ions suggests natural weathering of carbonate minerals and limited anthropogenic influence, making the spring water suitable for irrigation and drinking purposes. The clustering of data points within the Ca-Mg-HCO_3 field highlights consistent hydrochemical conditions across various locations. In the post-monsoon 2023 season, a gradual shift towards sodium (Na^+) enrichment is observed in some springs, indicating ion exchange reactions where Na^+ replaces Ca^{2+} and Mg^{2+} due to prolonged groundwater-rock interactions. This transition signifies a change in hydrochemical facies, potentially influenced by agricultural runoff, anthropogenic inputs, and reduced recharge following the monsoon period. Additionally, increasing chloride (Cl^-) and sulfate (SO_4^{2-}) concentrations in certain locations suggest enhanced solute accumulation, possibly linked to external contamination sources. The Piper plot reveals a broader dispersion of data points, reflecting variations in groundwater chemistry across different springs. By pre-monsoon 2024, the hydrochemical evolution is further pronounced, with increased dominance of sodium and potassium (Na-K) in some springs. The elevated Na^+ concentration suggests intensified ion exchange reactions, exacerbated by reduced recharge and evaporation effects. The reduction in bicarbonate levels, coupled with higher sulfate and chloride concentrations, indicates progressive mineral saturation and accumulation of solutes over time. The spatial spread of data points within the Na-K field suggests significant geochemical changes, warranting close monitoring for potential groundwater quality deterioration.

(a)



(b)



(c)

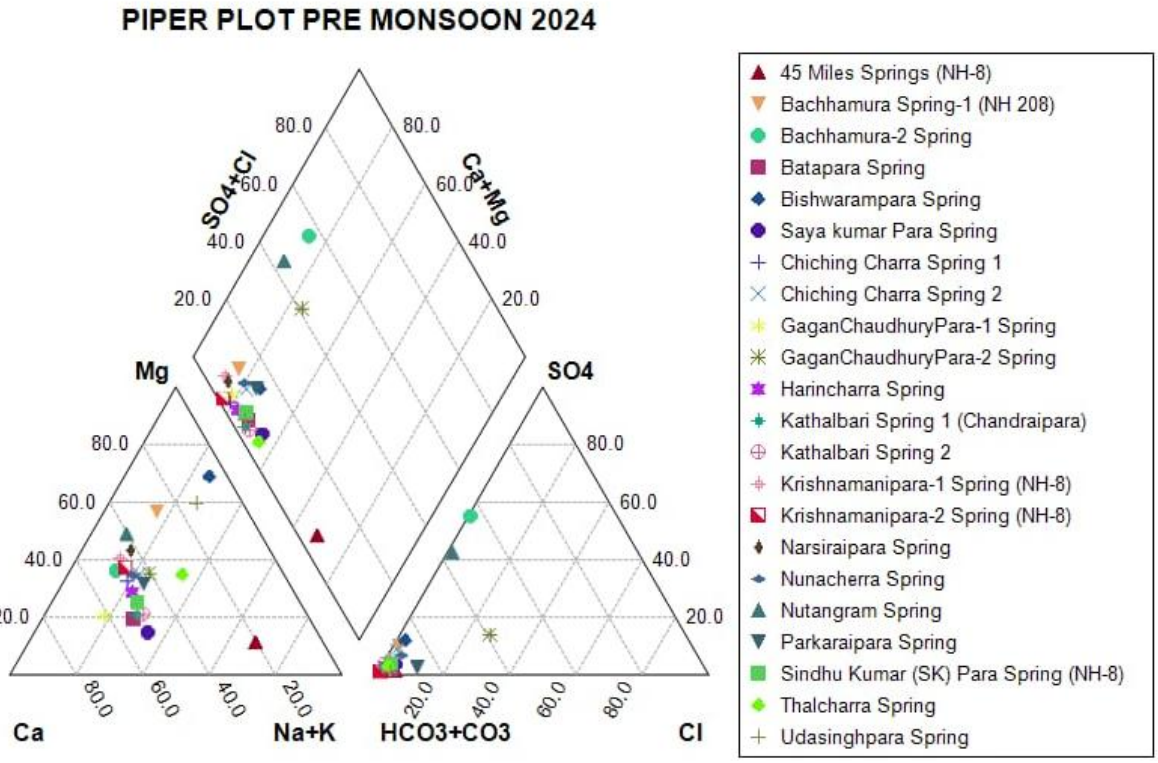


Figure 6-1: Piper plot for Spring water of Dhalai district (a) Monsoon 2023 (b) Post Monsoon 2023 and (c) Pre Monsoon 2024

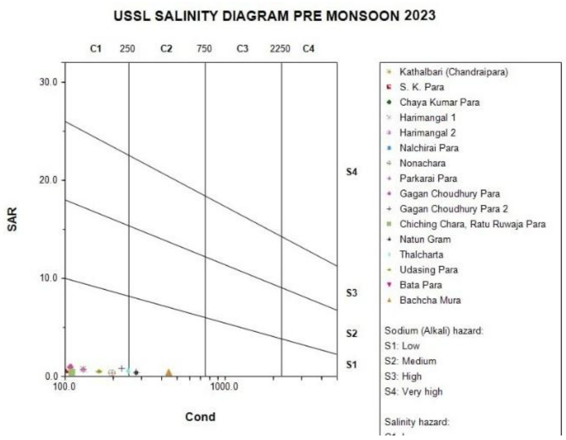
The comparative assessment of Piper plots across these three seasons underscores the dynamic nature of spring water chemistry in Dhalai district. The progressive shift from calcium-bicarbonate-dominated water to sodium-enriched compositions highlights the cumulative impacts of seasonal recharge, anthropogenic activities, and geological interactions.

6.5. USSL (UNITED STATES SALINITY LABORATORY) DIAGRAMS

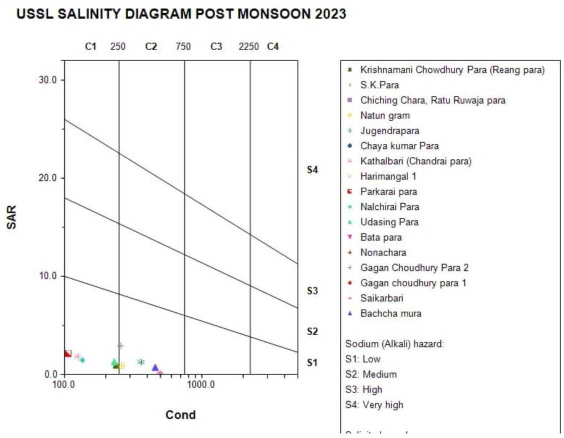
The USSL (United States Salinity Laboratory) diagrams for monsoon 2023, post-monsoon 2023, and pre-monsoon 2024 provide valuable insights into the hydrochemical evolution of spring water in Dhalai district, Tripura. These diagrams categorize water samples based on Sodium Adsorption Ratio (SAR) and electrical conductivity (EC), offering a detailed classification of sodium and salinity hazards across seasons.

The SAR values recorded across the three seasons illustrate a progressive increase in sodium dominance. During monsoon 2023, most springs exhibit low sodium hazard (S1), indicating minimal risks for soil permeability and structural deterioration. As the season transitions to post-monsoon 2023, several springs shift toward S2 and S3 classifications, reflecting increased sodium adsorption driven by longer groundwater residence time and ion exchange reactions. By pre-monsoon 2024, certain springs reach S4 (very high sodium hazard) levels, indicating severe risks to soil structure and fertility, which could negatively impact agricultural productivity. The electrical conductivity (EC) values highlight seasonal variations in salinity hazards. During monsoon 2023, most springs fall within C1-C2 classifications, indicating low to moderate salinity levels favourable for irrigation. However, post-monsoon 2023 sees a gradual rise in salinity concentrations, with some springs shifting to C3 (high salinity), suggesting increased mineral dissolution and salt accumulation. By pre-monsoon 2024, several springs exhibit C4 (very high salinity), reinforcing the need for groundwater management strategies to mitigate soil degradation risks.

(a)



(b)



(c)

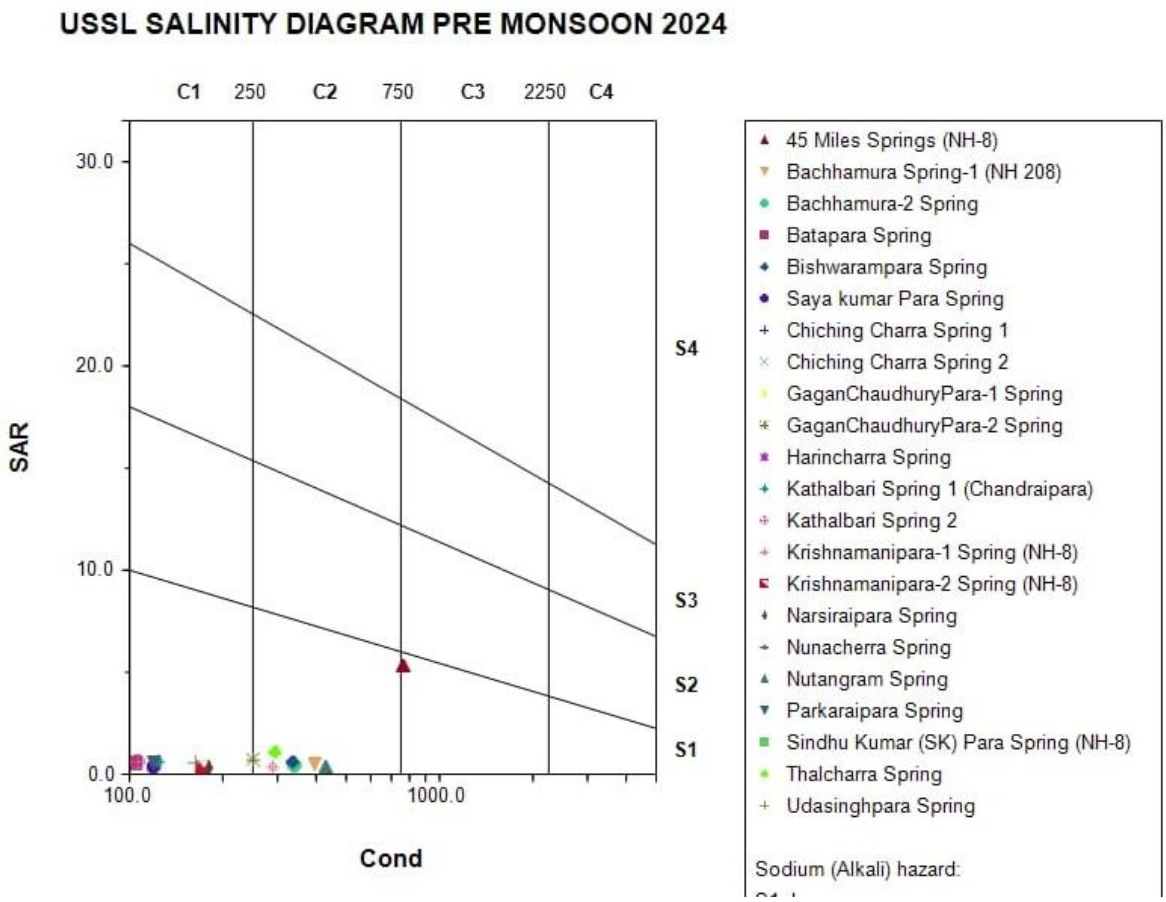


Figure 6-2: USSL Diagram for Spring water of Dhalai district (a) Monsoon 2023 (b) Post Monsoon 2023 and (c) Pre Monsoon 2024

The geochemical processes influencing these seasonal variations include ion exchange reactions, where sodium replaces calcium and magnesium, resulting in a shift from calcium-rich to sodium-rich groundwater. Additionally, evaporation effects are more pronounced in pre-monsoon 2024, leading to higher salinity concentrations. Anthropogenic impacts, including agricultural runoff, groundwater extraction, and localized contamination, further contribute to the evolving water chemistry in certain spring locations.

6.6. ASSESSMENT OF GROUND WATER QUALITY FOR FEASIBILITY IN IRRIGATION

The assessment of spring water in Dhalai district, Tripura, with respect to suitability for irrigation across monsoon 2023, post-monsoon 2023, and pre-monsoon 2024 seasons reveals significant temporal variations in key groundwater quality parameters, including sodium adsorption ratio (SAR), sodium percentage (% Na), and residual sodium carbonate (RSC) (refer Annexure for Datasheets).

During the monsoon season of 2023, SAR values ranged from 0.38 to 1.30, indicating minimal risks to soil permeability. However, in the post-monsoon period, SAR values increased, reaching up to 2.90 in some locations, suggesting a rising trend in sodium adsorption. This trend continued into the pre-monsoon 2024 season, where SAR values peaked at 5.31, highlighting potential concerns for soil degradation due to excessive sodium accumulation. Similarly, sodium percentage (% Na) exhibited an upward trend, with maximum values recorded at 51.59% in the monsoon season, increasing to 70.70% post-monsoon, before stabilizing within a range of 11.35% to 31.07% in the pre-monsoon phase. The variability in sodium concentration across seasons indicates dynamic groundwater chemistry influenced by recharge patterns, evaporation, and anthropogenic activities.

Residual sodium carbonate (RSC) values displayed seasonal fluctuations, with generally negative values in the monsoon and post-monsoon periods, signifying improved irrigation suitability. However, in the pre-monsoon season, RSC values varied widely from -2.10 to 4.31, with some locations exceeding safe thresholds, necessitating close monitoring to prevent potential impacts on soil and crop productivity.

The detailed data sheets have been summerised in the **Annexures 11.9.**

6.7. SUMMARY AND RECOMMENDATIONS

The water quality assessment for the springs in Dhalai district, Tripura, highlights key areas of concern and recommendations for sustainable water usage. Drinking water suitability has been evaluated based on Bureau of Indian Standards (BIS) guidelines, particularly for iron (Fe), and manganese (Mn) concentrations. While most springs met BIS-defined limits during the monsoon season, post-monsoon and pre-monsoon periods displayed increased mineralization due to reduced recharge rates and prolonged groundwater residence time. Iron and manganese concentrations levels exceeded the BIS permissible limits in some samples, necessitating mitigation strategies such as oxidation, filtration, or adsorption to ensure potability.

For irrigation suitability, parameters such as sodium adsorption ratio (SAR), residual sodium carbonate (RSC), and electrical conductivity (EC) were analyzed across seasons. The results indicate a progressive increase in sodium dominance, with SAR values rising from safe levels in monsoon 2023 to concerning thresholds in pre-monsoon 2024, where soil degradation risks become evident. Similarly, increasing sodium percentage (%Na) and varying RSC values emphasize the need for adaptive irrigation strategies. Springs classified under high salinity hazards (C3-C4) require proper drainage management and dilution techniques to sustain agricultural productivity. Gypsum application or organic amendments could mitigate soil degradation risks associated with elevated SAR.

The Piper plot interpretations reveal a gradual shift in groundwater chemistry from calcium-magnesium-bicarbonate (Ca-Mg-HCO3) dominance during the monsoon season to sodium-enriched compositions in the pre-monsoon period. This transition indicates ion exchange reactions, evaporation effects, and anthropogenic influences affecting water composition. Increased sodium and chloride levels in post-monsoon and pre-monsoon samples highlight the cumulative impacts of seasonal recharge variations and mineral dissolution. Similarly, the USSL (United States Salinity Laboratory) diagrams demonstrate progressive salinity increase, with certain springs reaching high-salinity classifications that could negatively impact soil permeability and crop productivity.

To ensure effective mitigation and long-term water sustainability, the implementation of tailored groundwater management plans based on seasonal hydrochemical trends is essential. Targeted interventions, such as advanced filtration methods for drinking water treatment, site-specific irrigation strategies, and community-based monitoring initiatives, will improve water quality while promoting environmental resilience.

7. SPRING WATER MANAGEMENT PLAN:

Spring plays a vital role in sustenance of life of hilly people. The community living in mountain since time immemorial considers spring water as the purest & scared water and it is respected. In some parts they protect it by construction of temple and shrine in those places even today some places have those structures preserved.

7.1. MAJOR ISSUES:

a) Land degradation is one of the major problems identified in the hilly. In the hilly tract of Dhalai Dist. of Tripura, the practice of Jhum cultivation is prevalent, which involve clearance of large chunk of forest using fires and therefore most of the forested lands were burned and currently are being used for beetle nut cultivation. This leads to serious soil erosion in those areas and causes landslide problem.

b) Road construction in the area is going on which aggravates the problems. Activities for controlled soil erosion and reclamation of eroded stretches are urgently required and communities should be encouraged to take up suitable measures such as vegetative barriers, contour bund, engineer structure like gabion, loose boulder, check dam etc.

c) The water supply in hills and mountain is mostly spring dependent. However, due to fluctuating discharge it is observed during lean periods the discharge decreases and water shortage occur. To maintain consistency of the flow throughout the year conservation of spring and its supply to the downstream along with its management is necessary.

d) Major factors responsible for declining discharge of a spring indicating that the spring needs rejuvenation are as follows:

- Indiscriminate deforestation in the recharge area and catchment area.
- Erratic rainfall in space and time.
- Forest fire in the recharge area, mainly during the summer season.
- Grazing and trampling by cattle in the recharge area.
- Erosion of the top, fertile soil.
- Other anthropogenic factors like construction of roads & buildings in the recharge area.

7.2. MANAGEMENT PLAN:

The two-fold management plan is to be given one recharging the aquifers through soil and water conservation structures in the area by identifying hydro-geological assessment & aquifers and other by community participatory approach.

The proposed spring serves as one of the major source of water for the inhabitants in the area. The spring water is collected using tankers to be supplied for various household uses. It has a discharge of 150 lpm during post monsoon season and the discharge declines in the lean period with a discharge of 6 lpm. There is a need to restore and preserve the spring from drying up. Supplementing the natural groundwater recharge, by first identifying the recharge area of the aquifers feeding the spring and then taking up artificial recharge works like digging trenches and ponds to catch the surface flow and enhance the infiltration forms the rejuvenation plan. It also involves the maintenance and protection of catchment of the spring and the spring head to ascertain that there is no danger of pollution to ensure safe water. It involves land use management and control from anthropogenic interference in the Springshed.

7.2.1. Spring development

Proper spring development helps to protect the water supply form contamination. The objective of spring development is to collect the flowing water underground to protect it from surface contamination and store it in a sanitary spring box.

A spring is developed by collecting the water that flows out of a spring or seep in a pipe to a watering trough. A spring can be developed in several different ways but generally the steps are:

a) Dig into the hillside to find the source of the spring or seep.
b) Put down gravel and perforated pipe to collect the water.
c) Build a dam of compacted soil, plastic sheeting, or concrete downstream from the gravel and allow to force the water into the pipe.
d) Run the pipe to a spring box to settle out dirt and sand.
e) Run a pipe from the spring box to a watering trough.

7.2.2. Concentrated spring development:

These springs occur along hillsides in mountain and piedmont areas at points where groundwater emerges naturally from openings in rock. These are the easiest springs to develop and protect from contamination. Proper development for concentrated springs consists of intercepting water underground in its natural flow path before it reaches the land surface. Concentrated spring found in valleys or other low areas is termed as low-area spring.

To develop a concentrated spring following steps are required:

a) Dig upslope from the spring outlet to a point where flowing water is at least 3 feet underground or where rock is encountered.

b) Install a rock bed to form an interception reservoir. On the down slope side, install a cutoff wall of concrete or plastic. The cutoff wall may not be necessary for a low-area spring, where the spring box may serve as the collector.

c) Insert a collector pipe low in the cutoff wall to guide water into the spring box. As much as possible, prevent water from backing up behind the wall.

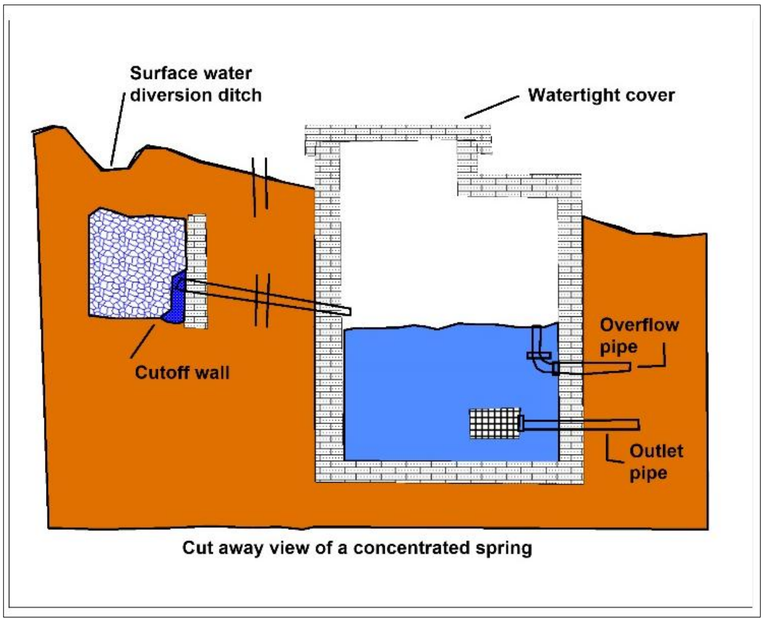


Figure 7-1: Cut-away view of a concentrated spring

7.2.3. Seepage spring development:

These generally occur where groundwater "*seeps*" from the soil over large areas. The development process for seepage springs consists of intercepting flowing groundwater over a wide area underground and channelling it to a collection point as shown in the figure below. Because seepage springs collect water over large areas, they are more difficult to protect from surface water contamination than concentrated springs.

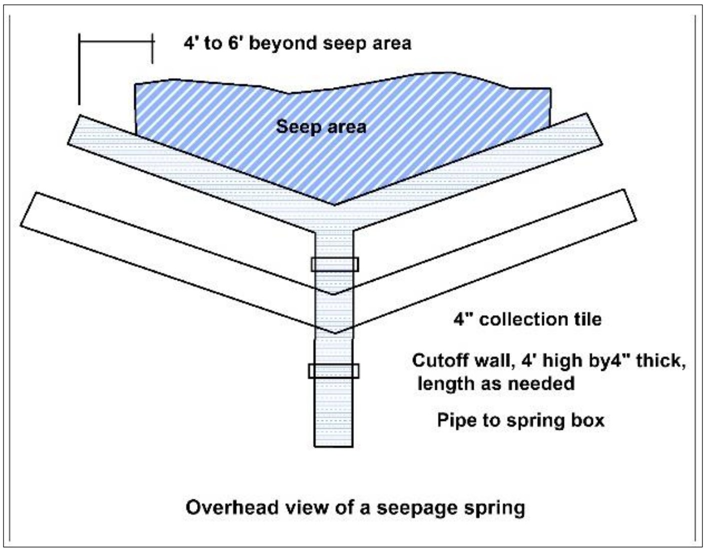


Figure 7-2: Overhead view of a seepage spring

Following steps are required to develop a *seepage spring*:

a) Dig test holes uphill from the seep to find a point where the impervious layer below the water-bearing layer is about 3 feet underground. Water flows on top of this layer in sand or gravel toward the surface seep.

b) Dig a 2-foot-wide trench across the slope to a depth of 6 inches below the water-bearing layer and extending 4 to 6 feet beyond the seep area on each side. Install a 4-inch *collector tile* and completely surround the tile with gravel.

c) Connect the collector tile to a 4-inch line leading to the spring box. The box inlet must be below the elevation of the collector tile.

d) The spring box should be watertight (most are made of reinforced concrete) and have a tight-fitting cover. It should be at least 4 feet tall and should extend at least 1 foot above ground level when buried. The size of the spring box depends on the amount of storage needed. Typically, it should be at least 3 square feet, which would provide storage of 511 litre with water standing 2 feet deep. If the size were increased to 4 feet square, the amount of storage would increase to 240 gallons with water standing 2 feet deep.

e) The spring box should have an *outlet pipe* and an *overflow pipe*. The overflow pipe should be screened and located below the collector pipe or tile so that water will not back up behind the spring.

7.3. SPRING DISINFECTION

During the survey it is noticed that the spring tab chambers are not properly cleaned periodically. As a result, algal growth (moss) inside the spring has developed inside the wall of the spring tab chamber. Therefore, time to time bacteriological test and periodical chlorination of each spring are needed.

Springs are often contaminated with bacteria during construction or maintenance. All new and repaired water systems should be disinfected using shock chlorination. If bacterial contamination occurs on a regular basis because of surface sources above the spring, continuous chlorination may be necessary.

The following are the steps to disinfect spring-fed water systems with chlorine:

1. Remove debris and sediment from the spring box and distribution system. Scrub all interior surfaces with a strong chlorine solution (1 gallon of liquid chlorine laundry bleach per 10 gallons of water). It may be ensued to wear gloves and other appropriate protective clothing
2. Disinfect the spring box by first allowing it to fill with fresh spring water. If the spring flow is small enough, plug the outlet pipe and add chlorine to the spring box to obtain the 200-part-per-million chlorine concentration as described above. Hold the chlorinated water in the spring box for at least 12 hours. Keep the overflow pipe open. If the flow rate is too high to retain water in the spring box, feed the chlorine solution into the spring box continuously for at least 12 hours.
3. Disinfect the water distribution system including pressure tanks, storage tanks, pipelines, valves, and faucets by pumping chlorinated water through the system. Open all faucets until a strong chlorine odour is detected at each one. Close the faucets to allow the chlorine solution to remain in the system for at least 12 hours.
4. Open all valves and faucets to allow fresh spring water to flow through the system until no chlorine odour or taste can be detected.
5. Test the spring water for bacterial contamination 24 hours after chlorine has been removed from the spring and household system.

Continuous chlorination is necessary if bacterial contamination continues after repeated shock chlorinations. In this system, equipment is used to feed chorine continuously in sufficient amounts to kill bacteria. Chlorine must be in contact with water at least 1 to 5 minutes to kill all bacteria. At the end of this time, a chlorine residual of about 3 to 5 ppm should remain to indicate that the disinfection is complete. Typical chlorine feed rates are about 1 cup of 5 percent laundry bleach per 300 gallons of water. This rate depends on water temperature, pH, and pumping rate. Use an inexpensive chlorine residual kit to determine if the feed rate should be increase of decreased to obtain the proper chlorine residual.

7.4. SPRINGSHED MANAGEMENT

7.4.1. Introduction

Springs form an essential source of freshwater in hilly and mountainous areas. In contrast to rivers and major lakes, springs frequently function as the sole dependable source of drinking water, irrigation, and domestic use for rural populations. In India, the Himalayas, Western Ghats and segments of the North-Eastern states are heavily reliant on natural springs. Yet, as a consequence of climate change, deforestation, land-use changes and growing demand for water, numerous springs are drying up or exhibiting decreased discharge.

Hence, springshed management has become an essential step to ensure future water security in hilly areas. Understanding the Hydrogeology, rainfall pattern, catchment area and involving participation of people in sustainable watershed management to conserve and develop springs in a systematic manner.

7.4.2. Concept of Springshed and Its Importance

A springshed is the contributing catchment area supplying groundwater to a specific spring. Like a watershed discharges rainfall into a stream or river, a springshed discharges rainwater into underground aquifers feeding a spring.

Significance in Hilly Regions:

- Major source of drinking water for dispersed habitations: Hilly regions usually have habitats spread as small villages which generally depends on Springs for domestic and drinking water.
- Provides irrigation for farming in terraces: Terrace cultivation generally requires less water since the leveled surfaces slow down runoff and allow more water to infiltrate into the soil. Under such conditions, springs can provide sufficient irrigation.
- Provides base flow to streams during periods of dryness: During the rainy season, streams are full because of runoff. But when there is no rainfall (dry periods), the stream would normally shrink, in such situation springs play a critical role. They continuously release groundwater into the stream, maintaining a minimum flow called base flow.
- Supports local ecosystems and biodiversity: Springs provide a continuous and clean water source, sustaining ecosystems even in dry periods. They create unique habitats, enrich soil with nutrients, and support diverse plants and animals. Serving as vital watering points, springs maintain ecological balance and act as biodiversity hotspots essential for local environmental stability.
- Serves as a lifeline for rural and indigenous people: Springs act as lifelines for rural and indigenous people by providing reliable drinking water, irrigation, and livestock needs. They support traditional livelihoods, reduce dependence on external sources, and sustain communities in remote, water-scarce hilly regions.

7.4.3. Causes of Spring Degradation in Hilly Regions

- Deforestation and Land Use Change: Cutting trees and converting forests to agriculture or settlements reduce infiltration and groundwater recharge. With less water entering aquifers, springs dry up, while runoff and soil erosion increase.

- Development (Roads, Buildings): Construction activities block or disturb natural recharge zones. Roads, pavements, and buildings reduce permeability, preventing water from percolating underground. This disrupts aquifers, lowering spring discharge and altering natural flow patterns.
- Over-pumping of Groundwater from Borewells: Excessive extraction through borewells lowers the water table. When aquifers are overdrawn, springs lose their pressure head, leading to reduced discharge or complete drying of spring outlets.
- Climate Variability: Unpredictable rainfall and reduced snowfall affect recharge cycles. Less snowmelt and erratic monsoon rains lower groundwater storage, making springs unreliable and seasonal instead of perennial in many hilly regions.
- Soil Erosion: Topsoil loss reduces water-holding and infiltration capacity. Eroded slopes fail to recharge aquifers effectively, lowering subsurface water storage and spring flow, while sedimentation may block underground pathways feeding springs.
- Population Pressure: Rising demand for domestic, agricultural, and livestock needs stresses limited spring resources. Overuse, pollution, and competing demands often exceed natural recharge, resulting in degradation and drying of spring systems.

7.4.4. Principles of Springshed Management

Springshed management combines hydrogeology and community-based conservation. Its major principles are:

- Knowing the Hydrogeology: Understanding aquifers, recharge zones, and flow directions helps identify spring sources. Scientific mapping ensures effective conservation, targeted recharge interventions, and sustainable spring revival in hilly landscapes.
- Recharge Improvement: Enhancing groundwater recharge through trenches, pits, percolation tanks, and forest regeneration increases infiltration. These measures restore aquifers, stabilize spring discharge, and reduce seasonal drying, ensuring long-term water availability.
- Demand Reduction: Water conservation practices like rainwater harvesting, efficient drip irrigation, and reducing wastage balance demand with supply. This minimizes stress on springs, ensuring sustainable use and equitable resource distribution.
- People's Involvement: Local communities act as custodians of springs. Their participation in planning, monitoring, and maintenance builds ownership, strengthens traditional knowledge, and ensures long-term sustainability of springshed management interventions.
- Institutional Support: Collaboration between government, NGOs, and scientific institutions provides technical expertise, financial backing, and policy support. Such partnerships strengthen community efforts, scale up successful practices, and ensure sustainable spring management.

7.4.5. Springshed Management Techniques in Hilly Regions

Springshed management relies on a combination of physical, biological, scientific, and community-based measures to ensure sustainability. Recharge improvement measures such as trenches, contour bunds, staggered trenches, recharge ponds, check dams, infiltration pits, and revival of traditional water harvesting structures enhance groundwater percolation. Vegetative measures, including afforestation of recharge zones, protection of vegetation and grass plantation plays a vital role in reducing soil erosion and maintaining ecosystem balance. The use of scientific tools like GIS and Remote Sensing for mapping, hydrogeological surveys to identify recharge–discharge areas, monitoring of spring discharge and water quality provide insight to take steps for judicious use sustainable management of springs. Involvement of citizen and policy interventions, where village-level water governance committees, awareness & training programs and convergence with schemes such as MGNREGA, Jal Jeevan Mission, and watershed programs ensure active participation, technical support and long-term sustainability of spring systems.

7.4.6. Case Studies

- Sikkim Model (India): The Sikkim's Dhara Vikas Programme has been able to rejuvenate more than 100 springs by recharge ponds, trenches, and community participation. The model is now being extended to other Himalayan states.
- Himalayan Region: NGOs like ACWADAM and People's Science Institute (PSI) have shown the way how planning based on hydrogeology can help restore springs and enhance water security in Uttarakhand and Himachal Pradesh.
- Nepal: Springshed management in mid-hill villages has enhanced irrigation for terracing farming, resulting in improved crop production and curtailment of migration.

7.4.7. Challenges

- Challenging Terrain: Steep slopes in hilly regions make construction of recharge structures difficult, inaccessible, high costs and risk of landslides often restrict implementation of springshed management measures.
- Absence of Technical Skills: Rural communities often lack hydrogeological knowledge and technical expertise needed for designing and maintaining recharge systems. Without proper training, springshed interventions remain ineffective.
- Inadequate Funds and Maintenance: Lack of funds limits bigger projects. Poor maintenance of existing structures causes the structures to weaken over time, reducing their usefulness in the long run.
- Climate Change Uncertainty: Irregular rainfall pattern, reduce groundwater recharge. These climate changes make spring flow uncertain, putting water security at risk for hilly communities that depend on springs.

7.4.8. Role of CGWB in Springshed Management

Central Ground Water Board (CGWB) under the Ministry of Jal Shakti has recognized that springs are an important water source in hilly and mountain areas but many are drying up. To address this, CGWB has mapped and recorded springs under NAQUIM, preparing a National Aquifer Atlas with focus on the Himalayas and North-East. It studies recharge zones, aquifers and spring flow and provides guidelines and GIS-based tools. Pilot projects with NGOs and states show how trenches, percolation tanks, check dams and afforestation can help recharge springs. CGWB also trains officials, engineers and community workers and shares handbooks and awareness programs. It works with NITI Aayog, UNDP, World Bank and NGOs to promote spring management. At the policy level, it has linked spring rejuvenation with Jal Jeevan Mission, MGNREGA and watershed schemes. Overall, CGWB mainly provides scientific support and guidance while actual work is done by states, NGOs and local communities.

7.4.9. Jal Sanchay, Jal Bhagidari (JSJB) and Springshed Management

Jal Sanchay Jal Bhagidari (JSJB), the vision of CGWB that links water conservation with people's participation for managing springs in hilly areas. Jal Sanchay focuses on recharge works like trenches, percolation tanks, and protecting catchments, while Jal Bhagidari stresses community involvement, making villagers, NGOs, and Panchayati Raj institutions caretakers of springs. This approach combines scientific methods with traditional knowledge, encourages teamwork among different groups, and ensures that local people become partners, helping in the revival and long-term sustainability of drying springs.

7.5. CONCLUSION:

Agriculture, though not much, is still the main occupation of the poor rural people. Only 3% of the total geographical area is sown. Whatever cultivation is practiced is shifting or Jhum cultivation. In this district, there is no major or medium irrigation project. There are only few minor irrigation schemes in the Block. The existing irrigation schemes are based mainly on surface water.

Springshed management is not merely water conservation; it's the survival of hill communities. In the hill tracts, where groundwater management in the conventional manner is difficult, springs are nature's treasure. Conservation and restoration of these through strategic springshed management provide water security, environmental harmony, and socio-economic prosperity. Understanding springs as an important resource, to develop them scientifically and to make local people custodians of their own water heritage.

Water level is found to occur between 2 to 15 m bgl. Ground water is found to occur under confined to semi-confined conditions with low yield of 5-15 m hr. Water level is found to rest between 2 and 4 m bgl.

Spring is a concentrated discharge of ground water appearing at the ground surface as flowing water. The study was carried out to know the genesis of springs and their present status of utilization for rural drinking water and agriculture, quality aspect with further scope of development. During the study 38 springs covering all the blocks were studied. The discharge of the springs was monitored in different seasons. The nearby rock type study was also carried out accompanied by discussion with local people to know the genesis of the springs. It is observed that topographic, contact and fracture springs are prevalent in this district. Proper spring development helps protect the water supply from contamination.

During the study it is observed that how far the rural people are presently dependent on spring water for their drinking water and irrigation purpose. Though no such data is available with the state govt. that how many household is supplied by using springs or how much cultivated area is irrigated through spring water but, field observation reviles that a good number of people are dependent on spring water both for their drinking water and for agricultural purpose.

To know about the chemical quality of the spring water samples were collected and analysis shows that except iron, all other parameters are within desirable limit for all useful purposes. Iron content is as high as 6 mg/lt as observed in one spring at kathalbari. Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity to determine if surface-water contamination is a problem. Springs are often contaminated with bacteria during construction or maintenance. All new and repaired water systems should be disinfected using shock chlorination. In a good number of springs tab chamber algal growth has been observed inside the chamber which needs periodical cleaning.

It is fairly unlikely to recommend any of the spring in the Dhalai Dist. for recharging surplus spring water, as the discharges of these spring are very little because of the small catchment/Springshed area and hilly slope.

7.6. RECOMMENDATIONS:

1. Each spring, whether seasonal or perennial, should be given due importance. During lean period when rural villagers suffer from water crises a very low discharge spring can cater a part of their daily water requirement.
2. Long term spring discharge trend analysis shows that, the spring discharge shows a declining trend. It is observed in some localities that in the upstream side of the spring catchment deforestation, construction of house as well as agricultural practice are going on and thereby loss of soil cover is prevalent. It is required to stop, at least by a forestation. Therefore, spring catchment area should be developed and protected.
3. Dhara Vikas is a government sponsored program to increase the discharge of springs in rural Sikkim. It is modeled with the idea of protecting a spring's catchment area and to provide recharge of its aquifer by installation of trenches in barren lands and drains

in cultivated land, gives rainwater a place to rest and percolate down into the ground water. Here a spring catchment area is traditionally developed by the villagers for its sustainable use. In the upstream of the spring small ponds like structures needs to be constructed to store the surface and rainwater. On way the stored water is recharging the ground water and the nearby spring in the downstream is getting direct benefit and thereby running throught the year. If scientific method as recommended in the Dhara Vikash programme is blended with the traditional approach and replicated in the district, rural people are sure to get benefit of it. But, development efforts should be spend first on the springs that affect the largest number of people as to more efficiently allocate government money.

4. Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity to determine if surface-water contamination is a problem. During survey it is noticed that spring tab chambers are not properly cleaned periodically. As a result algal growth (moss) has developed inside the wall of the spring tab chamber.
5. Time to time bacteriological test and periodical chlorination of each spring are needed. Now-a-days PHED, Govt. of Meghalaya is having district level chemical laboratory. Owner of each spring need not require running for a long distance to analyse water. The same practice should also be followed in Tripura.

The sustainability of spring depends on awareness of community as well as their active participation during as well as after spring development for their periodical maintenance and monitoring. It may not be possible for any government to take necessary attention in time for individual springs. Therefore, formation of a village committee with proper training is needed.

8. NGO’s AND COMMUNITY PARTICIPATION IN SPRINGSHED MANAGEMENT

8.1. INTRODUCTION:

Community Participation for Springshed Management: Planning of treatment measures in the recharge should be carried out area with the help of community participation. All the measures must be understood and managed by the involved communities. Hence there is requirement of good community mobilization to ensure the sustainability of the Springshed management. Social mobilization is also necessary for ensuring gender and social equity and for conflict resolution during the process of designing and implementing protocols.

Community participation plays a pivotal role in springshed management in Tripura, ensuring sustainability, inclusivity, and long-term success of water conservation efforts. Local communities, being the primary stakeholders and beneficiaries of spring resources, are actively involved in various stages of planning, implementation, and maintenance of springshed development initiatives. Through awareness programs, capacity-building workshops, and participatory rural appraisals, villagers are sensitised about the importance of springs and the need for their protection and rejuvenation. Community-led initiatives such as the construction of recharge structures, afforestation drives, and regular monitoring of spring discharge foster a sense of ownership and responsibility. Support from NGOs, government departments, and CSR partners further strengthens this collaborative approach. In Tripura’s hilly regions, this grassroots participation has proven crucial in reviving drying springs, improving water security, and promoting sustainable livelihoods

8.2. THE STATE GOVERNMENT:

At present, the state does not have a dedicated cell for springs; however, efforts are underway to constitute a Spring Cell comprising representatives from PWD (Water Resources), PWD (Drinking Water & Sanitation), CGWB, GSI, and other relevant line departments. The Central Ground Water Board (CGWB) has already conducted a spring inventory in the districts of North Tripura and Dhalai. As part of innovative water supply schemes, several of these inventoried spring discharges have been effectively tapped by PWD (DWS) to support local water supply needs. Meanwhile, both direct and indirect springshed development initiatives are being undertaken by multiple stakeholders. These include the Forest Department, Government of Tripura, and the Rural Development Department through MGNREGA. Additionally, private and non-governmental efforts are contributing to this cause, notably through initiatives led by CML, Tata Trust under CSR, and various other NGOs, alongside active community-led management practices.

8.3. THE FOREST DEPARTMENT, GPVERNMENT OF TRIPURA:

Under various Government of India schemes, the Forest Department of Tripura has been actively implementing a range of groundwater recharge structures, particularly across the hilly terrains of the state. These efforts are supported through key initiatives such as CAMPA, the 15th Finance Commission, MGNREGA in collaboration with the Rural Development Department and SCATFORM. Afforestation continues to remain a major thrust area under these schemes. To enhance groundwater recharge and ecosystem restoration, the department is constructing critical structures including trenches, check dams, nala bunds, and ponds or reservoirs (Amrit Sarovars), contributing significantly to the sustainable management of the state's water resources.

Figure 8-1: The initiative taken by the state government of Tripura towards afforestation and water conservation

8.4. CML, A TATA TRUST INITIATIVE:

As part of its Corporate Social Responsibility (CSR) initiatives, TATA TRUST, through Centre for Microfinance and Livelihood (CML) an NGO, has been actively engaged in the districts of Dhalai and North Tripura, aligning its efforts with the spring inventory carried out by the Central Ground Water Board (CGWB). The Team was Introduced to the State Government of Tripura through the State Unit Office, Central Ground Water Board. The intervention primarily focuses on enhancing spring recharge and promoting sustainable water resource management. Key activities under this initiative include the construction of staggered trenches and percolation tanks, along with robust efforts toward community sensitisation and participation. These measures aim to foster community ownership while strengthening the overall resilience of water resources in the region.

Some of the work they undertook for the springs inventoried by CGWB in North Tripura in the Jampui Hills are:

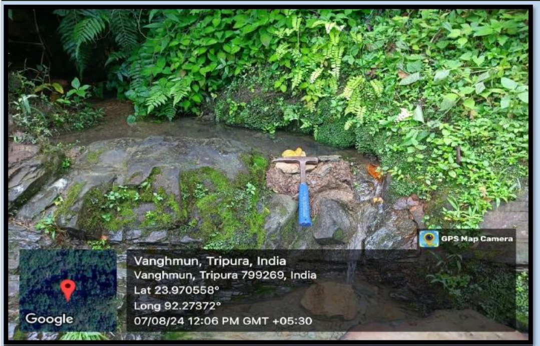
1. Tlangsang-1 spring

District	North Tripura
Block	Jampui Hills
Gram Panchayat	Tlangsang
Village Name	Tlangsang
Spring Name	Tlangsang_1 spring
Latitude	23.90604°
Longitude	92.270498°
Elevation (MSL)	701 m
Spring Seasonality: Perennial/ Seasonal	Perennial with low discharge during the lean season period
Discharge in litre per minute(lpm) D=V/T	1 LPM (July month)
Spring Typology	Depression
Usage	Drinking and domestic
Spring dependency (HHs)	50
Optional Drinking Water Source	JJM water supply scheme (Dysfunctional)
Land Ownership	Private
Land Use Type:	Areca nut plantation with sparse forest
Slope Aspect: (N/S/E/W/NE/NW/SE/SW)	W266°
Recharge Area (Ha)	1.8
Treated area (ha)	1.5
Rock Type	1. Colluvium deposits contained ill-sorted, angular sediments 2. Consolidated sandstone

3. Banglabari-1 spring

District	North Tripura
Block	Jampui Hills
Gram Panchayat	Tlangsang
Village Name	Banglabari
Spring Name	Banglabari_1 spring
Latitude	23.936371°
Longitude	92.279686°
Elevation (MSL)	611 m
Spring Seasonality: Perennial/ Seasonal	Perennial with low discharge during the lean season period
Discharge in litre per minute(lpm) D=V/T	2.1 LPM (May month)
Spring Typology	Depression cum contact
Usage	Drinking and domestic
Spring dependency (HHs)	30
Optional Drinking Water Source	JJM water supply scheme (Dysfunctional)
Land Ownership	Private
Land Use Type:	Community forest with sparse vegetation
Slope Aspect:	WS 212°
Recharge Area (Ha)	3.2
Treated area (ha)	2
Rock Type	1. Colluvium deposits contained ill-sorted, angular sediments 2. Sandstone with alternate clay layer

5. Behliangchhip_1 spring



District	North Tripura
Block	Jampui Hills
Gram Panchayat	Vanghmun
Village Name	Behliangchhip
Spring Name	Behliangchhip_1 spring
Latitude	23.971114°
Longitude	92.278194°
Elevation (MSL)	667 m
Spring Seasonality: Perennial/ Seasonal	Perennial with low discharge during the lean season period
Discharge in litre per minute(lpm) D=V/T	0.82 LPM (May month)
Spring Typology	Fracture
Usage	Drinking and domestic
Spring dependency (HHs)	60
Optional Drinking Water Source	JJM water supply scheme (Dysfunctional)
Land Ownership	Private
Land Use Type:	Areca nut plantation with sparse vegetation
Slope Aspect:	NNE88°
Recharge Area (Ha)	1.4
Treated area (ha)	1.1
Rock Type	1. Silty shale 2. Sandstone with alternate clay layer

Figure 8-2: The initiative taken by the CML, TATA Trust towards afforestation and protection of spring with springshed development

Figure 8-3: The initiative taken by the CML, TATA Trust towards springshed development

Figure 8-4: The support provided by CGWB to CML, TATA Trust towards springshed development

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11. ANNEXURES

11.1. DATASHEET (Spring Location details):

Sl No.	District	Block	Name/ID	Spring ID	Identification / Remark	Latitude	Longitude	Elevation in Mtr	Type	Spring Chamber	Geology			Land cover	Public Dependency	Vulnerability	
											Group	Formation	Observed Lithology			Spring	Spring shed
1	Khowai	Mungiakami	**43 Miles Springs (NH-8)**	**TR/KH/01**	*The Spring is located along NH-8 at 43 Miles Village. This spring has Spring Chamber*	23.90347	91.75220	201.32	Fracture Spring	Yes	Surma	Bokabil	Dark Shale	Along the roadside with springshed area High in the Hills	Yes, Villagers	No	No
2	Khowai	Mungiakami	**44 Miles Spring**	**TR/KH/04**	*The Spring is located along NH-8 at 44 Miles Village, A Blue Pipe connected for water, Located in between two Hillock*	23.90051	91.75797	168.53	Fracture Spring	No	Surma	Upper Bhuban	Dark Shale	Along the roadside with springshed area High in the Hills	Yes, for Drivers	Yes	No
3	Khowai	Mungiakami	**47 Miles Spring**	**TR/KH/03**	*The Spring is located along NH-8 at 47 Miles Village, White Pipe near the Culvert, The Spring is on the Top of the Hillock*	23.89007	91.76943	189.20	Contact Spring	No	Surma	Upper Bhuban	Dark Shale to Light Silt	Along the roadside with springshed area High in the Hills	Yes, for Drivers	Yes	No
4	Dhalai	Salema	**Bachhamura Spring-1 (NH 208)**	**TR/DH/19**	*The Spring is located along NH-208, Narrow elonggated Path with a Hole for the water to comeout*	24.10289	91.88827	152.26	Contact Spring	No	Surma	Upper Bhuban	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	Yes, for Drivers	Yes	Yes
5	Dhalai	Salema	**Bachhamura-2 Spring**	**TR/DH/21**	The Spring is located along NH-208, Spring Flowing in both the	24.10254	91.89066	166.61	Contact Spring	No	Surma	Upper Bhuban	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed	No	Yes	Yes

					directions from the spring outlet towards the Road									area High in the Hills			
6	Dhalai	Salema	**Bachhamura-3 Spring**	**TR/DH/23**	*The Spring is located along NH-208, A wet Patch below the Zebra Strip*	24.10645	91.87817	80.58	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
7	Dhalai	Salema	**Bachhamura-4, Dry Spring**	**TR/DH/24**	*The Spring is located along NH-208, Dry, Dark Iron Stain with Hole inbetween*	24.10186	91.87763	84.11	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
8	Dhalai	Salema	**Bachhamura-5, Dry Spring**	**TR/DH/25**	*The Spring is located along NH-208, Dry, Dark Patch with No Hole*	24.10168	91.87766	82.99	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
9	Dhalai	Salema	**Bachhamura-6 Spring**	**TR/DH/22**	*The Spring is located along NH-208, Amall Spring below a Dark Iron Stained Dry Patch*	24.10160	91.87768	81.63	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
10	Dhalai	Salema	**Bachhamura-7**	**TR/DH/31**	The Spring is located along NH-208, Under the Green Sheet covering Hills, Just before the Bridge	24.10133	91.87787	78.80	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
11	Dhalai	Salema	**Bachhamura-8**	**TR/DH/32**	The Spring is located along NH-208, A New Discharge coming Way far and goes below Bachhamura-1 Spring	24.10381	91.88957	83.20	Contact Spring	No	Surma	Upper Bhuban	Yellowish Brown Siltstone/Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes

12	Dhalai	Ganganagar	**Batapara Spring**	**TR/DH/17**	*Along the River under a under construction Bridge*	23.74977	91.80360	94.54	Contact Spring	No	Tipam	Tipam sandstone	Dark Sandstone	On a Steep Slope, near the river	Yes, Villagers	No	No
13	Dhalai	Chawmanu	**Bishwarampara Spring, Left small Cherra**	**TR/DH/07**	*Below the Bridge, the Left Stream of Cherra*	23.80710	91.98068	66.27	Contact Spring	No	Surma	Bokabil	Dark Silt stone	Near the stream	No	No	No
14	Dhalai	Chawmanu	**Bishwarampara Spring, Whole Cherra**	**TR/DH/34**	*Below the Bridge, It's the discharge of the whole Cherra*	23.80710	91.98068	66.27	Contact Spring	No	Surma	Bokabil	Dark Silt stone	Near the stream	No	No	No
15	Dhalai	Manu	**Chiching Charra Spring 1, Ratu Ruwaja Para**	**TR/DH/13**	*Main Spring with High Discharge, Black Fossil Wood*	23.97333	92.05091	92.72	Fracture Spring	No	Tipam	Tipam sandstone	Dark Shale with Fossilised Wood	Forested area, being used by the Public	Yes, Villagers	No	No
16	Dhalai	Manu	**Chiching Charra Spring 2**	**TR/DH/20**	*Just infront of the First Spring, with Huge Iron Stain*	23.97332	92.05085	94.97	Contact Spring	No	Tipam	Tipam sandstone	Dark Shale with Fossilised Wood	Forested area, being used by the Public	Yes, Villagers	No	No
17	Dhalai	Ambasa	**GaganChaudhury Para-1 Spring**	**TR/DH/11**	*The Spring is about 9 to 10 m below the village, Yellow Sandstone*	23.82816	91.89470	109.21	Depression Spring	No	Tipam	Tipam sandstone	Yellow Sandstone	Jhum Cultivation, its near the Pond	Yes, Villagers	No	Yes
18	Dhalai	Ambasa	**GaganChaudhury Para-2 Spring**	**TR/DH/12**	*The Spring is about 9 to 10 m below the village, Dark Shale*	23.82918	91.88949	146.25	Contact Spring	No	Tipam	Tipam sandstone	Dark Grey Standstone and Shale Contact	In a Gorge, Difficult to Access	Yes, Villagers	Yes	Yes
19	Dhalai	Ambasa	**Harincharra Spring**	**TR/DH/06**	*Only the Main Channel of the Array of Springs*	23.85146	91.88055	97.62	Contact Spring	No	Tipam	Tipam sandstone	Yellow friable Standstone	Starting point of a Cherra	Yes, Villagers	No	No
20	Dhalai	Ambasa	**Harincharra Spring (Composite Discharge)**	**TR/DH/30**	*The Total Discharge of the Springs from all its mouth*	23.85146	91.88055	97.62	Contact Spring	No	Tipam	Tipam sandstone	Yellow friable Standstone	Starting point of a Cherra	Yes, Villagers	No	No
21	Dhalai	Chawmanu	**Jogendrapara Spring (Mostly Dry)**	**TR/DH/04**	*On to, Narrow Road, RHS of Road, May be a seasonal High Discharge Water Outlet*	23.80026	91.98068	98.03	Contact Spring	No	Surma	Bokabil	Dark clay/siltstone	In the forest, seasonal	No	No	No
22	Dhalai	Ambasa	**Kathalbari Spring 1 (Chandraipara)**	**TR/DH/02**	*Along the river, by the side of Agricultural Field &*	23.91997	91.89004	79.61	Contact Spring	No	Tipam	Tipam sandstone	Yellowish Sandy Clay	Along the side of the river	No	No	No

					Bridge , Left when you get down												
23	Dhalai	Ambasa	**Kathalbari Spring 2**	**TR/DH/26**	*Along the river, by the side of Agricultural Field & Bridge, same side of 1, Right, when u get down, A Small Pool of two Outlet, one with Fe Stain*	23.92015	91.89012	80.26	Contact Spring	No	Tipam	Tipam sandstone	Yellowish Sandy Clay	Along the side of the river	No	No	No
24	Dhalai	Ambasa	**Kathalbari Spring 3**	**TR/DH/27**	*Along the river, by the side of Agricultural Field & Bridge, opposite side of 1*	23.91982	91.88991	80.64	Contact Spring	No	Tipam	Tipam sandstone	Yellowish Sandy Clay	Along the side of the river	No	No	No
25	Dhalai	Ambasa	**Krishnamanipara-1 Spring (NH-8)**	**TR/DH/01**	*Just at the Boarder of Dhalai & Khowai Dist in the Curve, all Discharge, directly taken to village for Supply*	23.88318	91.78494	99.62	Fracture Spring	No	Surma	Bokabil	Dark Shale, Fractured	Along the roadside cutting with springshed area High in the Hills	Yes, Villagers	No	No
26	Dhalai	Ambasa	**Krishnamanipara-2 Spring (NH-8)**	**TR/DH/28**	*About 250 m from Boarder of Dhalai & Khowai Dist , along the Road*	23.88485	91.78586	106.66	Fracture Spring	No	Surma	Bokabil	Dark Shale, Fractured	Along the roadside cutting with springshed area High in the Hills	Yes, for Drivers	No	No
27	Dhalai	Ganganagar	**Narsiraipara Spring**	**TR/DH/08**	*Narrow Cave Like Structure, with water pondage. Way below the road, Grey Sandstone*	23.69147	91.85296	135.24	Contact Spring	No	Tipam	Tipam sandstone	Dark Grey Standstone and Shale Contact	forested area, a pool in a cave	Yes, Villagers	No	No
28	Dhalai	Ganganagar	**Nunacherra Spring**	**TR/DH/09**	*Near Our NHNS Well, Very Little Discharge,like a seepage spring*	23.78743	91.85537	128.88	Fracture Spring	No	Tipam	Tipam sandstone	Dark Grey Standstone	Along the side of the Road	Yes, Villagers	No	No
29	Dhalai	Chawmanu	**Nutangram Spring**	**TR/DH/14**	A small Cherra Left to the Main Cherra, Take Left from	23.86863	92.00636	95.26	Contact Spring	No	Tipam	Tipam sandstone	Dark Grey Standstone	Under the Jhum Cultivation	Yes, Villagers	No	No

					Shop, Way below, difficult to access											
30	Dhalai	Ambasa	**Parkaraipara Spring**	**TR/DH/10**	*Way below the Village Level (Water deposits in Tank)*	23.83200	91.89168	142.41	Contact Spring	No	Tipam	Tipam sandstone	Grey friable Standstone in contact with Shale	Forested area	Yes, Villagers	No	No
31	Dhalai	Manu	**Saikarbari Spring (NH 208)**	**TR/DH/18**	*Running, a Pipe by the side of Roa, near a Zebra Strip*	24.10889	91.91077	216.36	Contact Spring	No	Surma	Upper Bhuban	Yellowish Brown Siltstone and grey Shale	Along the roadside cutting with springshed area High in the Hills	Yes, for Drivers	Yes	Yes
32	Dhalai	Manu	**Saikarbari Spring-2 (NH-208), Dry**	**TR/DH/29**	*Dry, A Sink Cement Water Way below*	24.11137	91.91166	225.41	Contact Spring	No	Surma	Bokabil	Yellowish Brown Siltstone & grey Shale	Along the roadside cutting with springshed area High in the Hills	No	Yes	Yes
33	Dhalai	Chawmanu	**Saya kumar Para Spring**	**TR/DH/05**	*Along the River, Bigh Sand stone Tank*	23.82311	91.98372	90.83	Depression Spring	No	Tipam	Tipam sandstone	Yellowish/Greyish Fiable Sandstone	Forested, Jhoom Cultivation	Yes, Villagers	No	Yes
34	Dhalai	Manu	**Sindhu Kumar (SK) Para Spring (NH-8)**	**TR/DH/03**	*The Spring is located along NH-8, With a Big Tank on the Road connected by a Pipe from Spring*	23.94665	91.95963	95.33	Fracture Spring	No	Surma	Bokabil	Grey Shale/Siltstone	Forested area and outlet is towards road	Yes, Villagers	No	No
35	Dhalai	Chawmanu	**Thalcharra Spring (Small Outlet)**	**TR/DH/15**	*Near the Waterfall, a Small Outlet to the Right*	23.71281	92.04071	83.39	Fracture Spring	No	Tipam	Tipam sandstone	Grey Sandstone	Forested area Waterfall	Yes, Villagers	No	No
36	Dhalai	Chawmanu	**Thalcherra Water Fall, Cherra Discharge**	**TR/DH/33**	*Whole Cherra Discharge*	23.71281	92.04071	83.39	Fracture Spring	No	Tipam	Tipam sandstone	Grey Sandstone	Forested area Waterfall	Yes, Villagers	No	No
37	Dhalai	Ganganagar	**Udasinghpara Cherra Discharge**	**TR/DH/35**	*Way Below, Goo down near the Church, Down and Left, LHS of the Cherra (Curves)*	23.73132	91.87566	116.01	Contact Spring	No	Tipam	Tipam sandstone	Grey Sandstone	Forested area Waterfall	Yes, Villagers	No	No
38	Dhalai	Ganganagar	**Udasinghpara Spring**	**TR/DH/16**	*Way Below, Goo down near the*	23.73132	91.87566	116.01	Contact Spring	No	Tipam	Tipam sandstone	Grey Sandstone	Forested area Waterfall	Yes, Villagers	No	No

					Church, Down and Left, LHS of the Cherra (Curves)												
39	Khowai	Mungiakami	**45 Miles Artesian Well**	**TR/KH/02**	Near to our NHS Well Artesian Well	23.90068	91.76425	80.70	**Artesian Well**		Surma	Upper Bhuban	Yellowish Sandstone	Forested Area	Yes, Villagers		
40	Dhalai	Ambasa	**Harinchera Artesian Well**	**TR/DH/36**	Public Water Supply Tubewell	23.85183	91.88205	98.32	**Artesian Well**		Tipam	Tipam sandstone	Grey Sandstone	under PWD (DWS) water supply	Yes, Villagers		
41	Dhalai	Ambasa	**Iladhan Artesian Well**	**TR/DH/37**	Along the Roadside, Near Wall, Our Geophysical Site	23.90231	91.86684	77.58	**Artesian Well**		Dupitila	Dupitila	Grey Sandstone	In the Agricultural field, outlet toeards the road	Yes, Villagers		
42	Dhalai	Manu	**Vidyajoy Para Artesian Well**	**TR/DH/38**	Along the Road side on the way to Chichincherra	23.96325	92.04653	76.93	**Artesian Well**		Tipam	Tipam sandstone	Grey Sandstone	In the Agricultural field	Yes, Villagers		

11.2. DATASHEETS (Discharge in LPS, 2023-24)

Sl No.	Name/ID	ID	Discharge in LPS												Meinzer's Classification
			Apr-23	May-23	Jun-23	July-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Pre-2024
1	43 Miles Springs (NH-8)	TR/KH/01	0.0109	0.0121	0.0126	-	0.0153	-	0.0101	0.0097	0.0090	0.0106	0.0096	0.0131	**7**
2	44 Miles Spring	TR/KH/04	-	-	-	-	-	-	-	-	-	-	-	0.0128	**7**
3	47 Miles Spring	TR/KH/03	-	-	-	-	-	-	-	-	-	-	-	0.0070	**8**
4	Bachhamura Spring-1 (NH 208)	TR/DH/19	0.0253	0.0306	0.0353	-	0.0411	-	0.0420	0.0378	0.0345	0.0171	0.0153	0.0102	**7**
5	Bachhamura-2 Spring	TR/DH/21	-	-	-	-	0.0215	-	0.0178	0.0163	0.0144	0.0155	0.0135	0.0093	**7**
6	Bachhamura-3 Spring	TR/DH/23	-	-	-	-	0.0192	-	0.0203	0.0178	0.0157	0.0219	0.0184	0.0169	**7**
7	Bachhamura-7	TR/DH/31	-	-	-	-	-	-	-	-	-	-	-	0.0397	**7**
8	Bachhamura-8	TR/DH/32	-	-	-	-	-	-	-	-	-	-	-	0.0286	**7**
9	Batapara Spring	TR/DH/17	0.0130	0.0152	0.0191	-	0.0216	-	0.0214	0.0195	0.0171	0.0224	0.0263	0.0351	**7**
10	Bishwarampara Spring, Left small Cherra	TR/DH/07	0.0290	0.0350	0.0468	-	0.0511	-	0.0546	0.0460	0.0373	0.0520	0.0491	0.0406	**7**
11	Bishwarampara Spring, Whole Cherra	TR/DH/34	-	-	-	-	-	-	-	-	-	-	-	-	**-**
12	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	0.9615	1.1111	1.2500	-	1.5480	-	2.1645	1.6779	1.4451	1.4451	0.6878	0.6460	**5**
13	Chiching Charra Spring 2	TR/DH/20	0.0511	0.0606	0.0792	-	0.1036	-	0.1040	0.0873	0.0698	0.1370	0.0616	0.0630	**7**
14	Harincharra Spring	TR/DH/06	0.0769	0.0909	0.1250	-	0.1531	-	0.1414	0.1202	0.1012	0.2488	0.2927	0.1142	**6**
15	Harincharra Spring (Composite Discharge)	TR/DH/30	0.6536	0.7752	0.8881	-	1.1161	-	1.3158	1.2136	0.9980	1.1111	1.3158	0.8993	**5**
16	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	0.0179	0.0226	0.0300	-	0.0350	-	0.0459	0.0402	0.0336	0.0478	0.0399	0.0402	**7**
17	Kathalbari Spring 2	TR/DH/26	0.0029	0.0031	0.0039	-	0.0044	-	0.0044	0.0042	0.0039	0.0050	0.0100	0.0156	**7**
18	Kathalbari Spring 3	TR/DH/27	0.0090	0.0101	0.0120	-	0.0131	-	0.0138	0.0127	0.0116	0.0167	0.0217	0.0212	**7**
19	Krishnamanipara-1 Spring (NH-8)	TR/DH/01	0.1073	0.1138	0.1383	-	0.1504	-	0.2193	0.1953	0.1475	0.0952	0.0221	0.0562	**7**
20	Krishnamanipara-2 Spring (NH-8)	TR/DH/28	0.1266	0.1389	0.1876	-	0.2008	-	0.2315	0.2045	0.1821	0.1992	0.0584	0.0523	**7**
21	Narsiraipara Spring	TR/DH/08	0.0952	0.1250	0.1667	-	0.1883	-	0.2232	0.1745	0.1536	0.1502	0.2744	0.0940	**6**
22	Nunacherra Spring	TR/DH/09	0.0057	0.0064	0.0081	-	0.0089	-	0.0110	0.0101	0.0089	0.0129	0.0088	0.0084	**7**
23	Nutangram Spring	TR/DH/14	0.0116	0.0132	0.0155	-	0.0176	-	0.0168	0.0149	0.0134	0.0175	0.0160	0.0138	**7**
24	Parkaraipara Spring	TR/DH/10	0.0057	0.0064	0.0075	-	0.0084	-	0.0088	0.0084	0.0073	0.0080	0.0044	0.0043	**8**
25	Saikarbari Spring (NH 208)	TR/DH/18	0.0031	0.0035	0.0042	-	0.0048	-	0.0066	0.0057	0.0051	0.0079	0.0061	0.0082	**7**
26	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	0.0105	0.0114	0.0137	-	0.0146	-	0.0174	0.0153	0.0137	0.0474	0.0351	0.0336	**7**
27	Thalcharra Spring (Small Outlet)	TR/DH/15	0.0138	0.0152	0.0206	-	0.0236	-	0.0236	0.0202	0.0163	0.0197	0.0233	0.0196	**7**
28	Thalcherra Water Fall, Cherra Discharge	TR/DH/33	1.9011	1.5862	0.4300	-	0.5803	-	0.2843	0.1728	0.0927	0.1570	0.2430	0.1892	**6**
29	Udasinghpara Cherra Discharge	TR/DH/35	-	-	-	-	-	-	-	-	-	-	-	0.1160	**6**
30	Udasinghpara Spring	TR/DH/16	0.0131	0.0162	0.0216	-	0.0253	-	0.0309	0.0253	0.0206	0.0225	0.0160	0.0252	**7**
31	45 Miles Artesian Well	TR/KH/02	-	-	-	-	-	-	-	-	-	-	-	0.0101	
32	Harinchera Artesian Well	TR/DH/36	-	-	-	-	-	-	-	-	-	-	-	0.2924	
33	Iladhan Artesian Well	TR/DH/37	-	-	-	-	-	-	-	-	-	-	-	0.4480	
34	Vidyajoy Para Artesian Well	TR/DH/38	-	-	-	-	-	-	-	-	-	-	-	0.2072	
	Average Actual Rainfall in mm in Dhalai		**78.2**	**99.6**	**373.1**	**383.2**	**281.4**	**195.8**	**101.1**	**116.4**	**49.1**	**0.0**	**36.4**	**45.5**	

11.3. DATASHEETS (Discharge in LPS, 2024-25)

Sl No.	Name/ID	ID	Discharge in LPS												Meinzer's Classification
			Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Post-2024
1	43 Miles Springs (NH-8)	TR/KH/01	0.0404	0.1420	0.2634	0.4132	0.4630	0.3401	-	0.0921	-	0.0658	0.0556	0.0775	6
2	44 Miles Spring	TR/KH/04	0.0332	2.3000	0.9643	0.4030	0.5120	0.4030	-	0.2300	-	0.2300	0.1220	0.1359	6
3	47 Miles Spring	TR/KH/03	0.0111	1.8450	1.9841	1.1312	1.3263	0.8651	-	0.2735	-	0.2028	-	-	6
4	Bachhamura Spring-1 (NH 208)	TR/DH/19	0.0278	0.0744	0.1266	0.0596	0.0690	0.0508	-	0.0195	-	0.0172	0.1250	0.1351	7
5	Bachhamura-2 Spring	TR/DH/21	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Bachhamura-3 Spring	TR/DH/23	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Bachhamura-7	TR/DH/31	0.0791	0.2773	0.6136	0.3280	0.3864	0.3280	-	0.0549	-	0.0549	0.0549	0.0549	7
8	Bachhamura-8	TR/DH/32	0.0610	0.0658	0.0896	0.0852	0.1124	0.0775	-	0.0549	-	0.0549	-	-	7
9	Batapara Spring	TR/DH/17	0.0179	0.0321	0.0611	0.0607	0.0643	0.0431	-	0.0267	-	0.0233	0.0382	0.0446	7
10	Bishwarampara Spring, Left small Cherra	TR/DH/07	0.0800	0.2450	0.5790	0.5342	0.6450	0.3870	-	0.1675	-	0.1675	0.2234	0.2654	6
11	Bishwarampara Spring, Whole Cherra	TR/DH/34	0.2630	-	-	-	-	-	-	-	-	-	-	-	-
12	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	0.6150	0.9225	4.9020	5.8824	7.5758	3.1250	-	1.5723	-	1.3228	2.0000	2.3810	5
13	Chiching Charra Spring 2	TR/DH/20	0.0625	0.3546	0.8292	0.4000	0.4739	0.3125	-	0.2193	-	0.1953	0.0962	0.1142	6
14	Harincharra Spring	TR/DH/06	0.1597	0.1547	0.4149	0.5669	0.6427	0.4950	-	0.3837	-	0.3213	0.1511	0.1914	6
15	Harincharra Spring (Composite Discharge)	TR/DH/30	0.2630	0.2000	1.2523	1.1510	1.2800	1.1510	-	0.4580	-	0.4580	0.4580	0.4580	6
16	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	0.0455	0.0641	-	0.1661	0.1953	0.1404	-	0.0805	-	0.0647	0.0394	0.0478	6
17	Kathalbari Spring 2	TR/DH/26	0.0089	-	-	-	-	0.0259	-	0.0149	-	0.0130	0.0057	0.0071	7
18	Kathalbari Spring 3	TR/DH/27	0.0250	-	-	-	-	0.0162	-	0.0124	-	0.0093	0.0047	0.0059	7
19	Krishnamanipara-1 Spring (NH-8)	TR/DH/01	0.1695	0.7622	2.7027	3.5714	4.4248	2.6455	-	2.0408	-	1.5432	0.0400	0.0484	5
20	Krishnamanipara-2 Spring (NH-8)	TR/DH/28	0.1250	1.1000	2.9706	0.7570	0.8435	0.7570	-	0.6230	-	0.6230	0.1299	0.1548	6
21	Narsiraipara Spring	TR/DH/08	0.0800	0.5000	0.7032	0.6849	0.7576	0.5814	-	0.2843	-	0.2843	0.2843	0.2843	6
22	Nunacherra Spring	TR/DH/09	0.0047	0.0041	0.1401	0.0448	0.0523	0.0354	-	0.0216	-	0.0173	0.0075	0.0089	7
23	Nutangram Spring	TR/DH/14	0.0106	0.0400	0.0680	0.0430	0.0370	0.0370	-	0.0287	-	0.0287	0.0316	0.0351	7
24	Parkaraipara Spring	TR/DH/10	0.0040	0.0000	0.0427	0.0401	0.0495	0.0317	-	0.0189	-	0.0145	0.0120	0.0134	7
25	Saikarbari Spring (NH 208)	TR/DH/18	0.0500	1.5576	0.1059	0.1153	0.1285	0.0988	-	0.0548	-	0.0372	0.0146	0.0164	7
26	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	0.0333	0.1409	0.0403	0.2078	0.2634	0.1603	-	0.0912	-	0.0698	0.0529	0.0596	6
27	Thalcharra Spring (Small Outlet)	TR/DH/15	0.0145	0.1850	0.1970	0.2240	0.2870	0.2240	-	0.1040	-	-	-	-	6
28	Thalcherra Water Fall, Cherra Discharge	TR/DH/33	0.3520	0.6470	1.1020	1.1358	1.3760	1.1358	-	0.2843	-	0.2843	0.2843	0.2843	6
29	Udasinghpara Cherra Discharge	TR/DH/35	0.1420	0.1891	0.1040	0.1280	0.1345	0.1280	-	0.1728	-	0.1728	0.1728	0.1728	6
30	Udasinghpara Spring	TR/DH/16	0.0209	0.0416	0.0263	0.0274	0.0317	0.0230	-	0.1728	-	0.1728	0.1728	0.1728	6
31	45 Miles Artesian Well	TR/KH/02	0.0118	0.0127	0.0248	0.0297	0.0373	0.0257	-	0.0155	-	0.0127	0.0270	0.0319	
32	Harinchera Artesian Well	TR/DH/36	0.3690	0.3376	0.4125	0.4664	0.5800	0.3906	-	0.6667	-	0.5181	0.5000	0.6266	
33	Iladhan Artesian Well	TR/DH/37	0.6098	0.6849	0.7042	0.7299	0.8503	0.6702	-	0.8977	-	0.6831	0.7042	0.8026	
34	Vidyajoy Para Artesian Well	TR/DH/38	0.2857	0.2959	0.2989	0.3322	0.4174	0.2895	-	0.2749	-	0.2114	0.2358	0.2740	
	Average Actual Rainfall in mm in Dhalai		**22.7**	**611.1**	**677.0**	**324.0**	**475.5**	**152.4**	**178.1**	**17.4**	**15.6**	**0**	**25.725**	**35.55**	

11.4. NATIONAL HYDROGRAPH MONITORING STATIONS (NHNS) WELL DETAILS

Sl. no	Block	Village	Latitude	Longitude	Well Type	MP (m agl)	RL (m asl)	Depth (m or ft)	Dia (m or mm)	Water Level (m bgl)							
										Aug-23	Nov-23	Jan-24	Mar-24	Aug-24	Nov-24	Jan-25	Mar-25
1	Ambassa	**Ambassa**	23.923972	91.846944	DW	0.92	58.885	9.16 m	1.05 m	6.77	7.03	7.32	7.85	5.42	6.41	7.11	7.85
2	Ambassa	**Raipassa**	23.895443	91.824810	DTW	0.19	94	-	200 mm	-	-	-	-	-	-	2.65	3.1
3	Ambassa	**Lalchari**	23.934164	91.854444	DW	0.92	66	9.00 m	1.60 m	6.66	6.05	6.74	7.7	4.35	4.62	5.97	7.12
4	Chawmanu	**Chawmanu**	23.862222	91.998889	DW	0.822	59	8.80 m	1.20 m	1.36	1.26	1.27	1.23	0.86	0.97	1.04	1.13
5	Chawmanu	**Durgacherra**	23.899455	92.002145	DW	0.95	-	8.90 m	1.20 m	4.05	4.58	4.6	5.11	2.54	4.35	5.13	7.11
6	Chawmanu	**Amtali**	23.860741	91.997599	DTW	0.19	67	400 ft	320 mm	-	-	-	-	-	-	21.08	18.1
7	Durga Chowmuhani	**Durga Chowmuhani**	24.121667	91.860278	DW	0.8	47	7.80 m	1.10 m	2.26	2.58	2.83	3.28	1.78	2.3	3.19	3.72
8	Durga Chowmuhani	**Kamalpur**	24.169639	91.815000	DW	0.66	32.59	5.64 m	1.23 m	1.44	1.32	1.37	1.5	1.37	1.39	1.54	1.72
9	Durga Chowmuhani	**Kali Kumar Para**	24.108889	91.860000	DW	0.78	43	5.20 m	1.22 m	2.78	2.8	2.81	3.18	2.59	2.62	2.82	3.2
10	Durga Chowmuhani	**Sikarbari**	24.100648	91.894831	DW	0.83	-	7.70 m	1.02 m	-	-	-	-	4.15	4.35	5.11	6.3
11	Durga Chowmuhani	**South Manik Bhandar**	23.139613	91.814336	DTW	0.015	38	-	320 mm	-	-	-	-	-	-	Auto flow	Auto flow
12	Dumboornagar	**Much Kumbir Para**	23.591855	91.800751	DW	0.8	-	7.20 m	1.10 m	3.8	3.66	3.97	4.28	2.92	3.45	3.87	4.32
13	Ganganagar	**Nuna Cherra**	23.787222	91.855278	DW	0.83	106	6.66 m	2.56 m	1.15	1.12	1.19	1.53	1.17	1.12	1.22	1.5
14	Ganganagar	**Ganganagar**	23.779603	91.848479	DTW	0.05	141	-	200 mm	-	-	-	-	-	-	-	5.8
15	Manu	**Manu New**	24.002500	91.991944	DW	0.95	39.5	8.32 m	1.95 m	4.65	4.73	5.3	5.78	2.61	4.10	5.01	5.55
16	Manu	**Sindhu Kumar**	23.952500	91.960556	DW	0.9	55	8.44 m	1.12 m	2.22	2.58	3.3	3.6	1.35	2.65	3.28	3.68
17	Manu	**Jamircherra**	23.986340	91.983860	DTW	0.22	75	700 ft	200 mm	-	-	-	-	-	-	5.59	6.71
18	Raishyabari	**Chandra Kumar Para**	23.442083	91.922741	DW	0.85	-	7.00 m	3 m	1.13	3.93	4.33	4.35	3.55	3.86	4	4.42
19	Raishyabari	**Thakurcherra**	23.552655	91.862031	DTW	0.2	134	-	320 mm	-	-	-	-	-	-	-	18.65
20	Salema	**Abhanga New**	24.054139	91.830833	DW	0.77	58.695	8.15 m	1.14 m	1.93	2.3	3.04	3.91	0.98	1.85	3.57	4.53
21	Salema	**Singinala**	24.018244	91.833511	DW	0.96	-	6.20 m	1.2 m	3.02	2.82	2.99	3.14	2.54	2.74	2.03	3.15
22	Ultacherra	**Jagabandhupara**	23.646455	91.804825	DTW	0.2	104	-	200 mm	-	-	-	-	-	-	4.21	6.05

11.5. DATASHEETS (Monthly Rainfall in mm, 2022-2025):

Average Rainfall in Dhalai District of Tripura:

Sl No	Stations	January	February	March	April	May	June	July	August	September	October	November	December	Monsoon	Non Monsoon	TOTAL
1	Kamalpur	22.0	14.2	43.6	300.4	894.0	544.6	174.2	578.0	265.0	130.6	8.2	46.4	1692.4	1328.8	**3021.2**
2	Chawmanu	0.0	2.5	37.5	163.5	472.0	693.2	162.4	262.4	159.5	137.2	29.0	15.5	1414.7	720.0	**2134.7**
3	Gandacherra	0.0	1.5	18.8	235.5	756.8	676.8	385.2	157.1	67.1	122.1	5.2	9.6	1408.3	1027.4	**2435.7**
Avg (in mm)	**DHALAI**	**7.3**	**6.1**	**33.3**	**233.1**	**707.6**	**638.2**	**240.6**	**332.5**	**163.9**	**130.0**	**14.1**	**23.8**	1505.1	1025.4	**2530.5**

Year 2022:

Sl No	Stations	January	February	March	April	May	June	July	August	September	October	November	December	Monsoon	Non Monsoon	TOTAL
1	Kamalpur	22.7	53.1	81.9	63.2	460.1	323.4	164.6	469.8	164.2	204.2	0.0	2.3	1326.2	683.3	**2009.5**
2	Chawmanu	4.0	11.5	35.0	52.0	254.5	291.5	201.8	368.2	177.6	239.5	0.0	20.0	1278.6	377.0	**1655.6**
3	Gandacherra	6.7	5.2	9.2	27.2	264.3	377.6	155.2	139.2	202.3	201.9	0.0	2.2	1076.2	314.8	**1391.0**
2022	**DHALAI**	**11.1**	**23.3**	**42.0**	**47.5**	**326.3**	**330.8**	**173.9**	**325.7**	**181.4**	**215.2**	**0.0**	**8.2**	1227.0	458.4	**1685.4**

Year 2023:

Sl No	Stations	January	February	March	April	May	June	July	August	September	October	November	December	Monsoon	Non Monsoon	TOTAL
1	Kamalpur	0.0	0.0	110.4	95.6	140.7	535.8	316.6	279.0	197.0	127.6	84.6	49.0	1456.0	480.3	**1936.3**
2	Chawmanu	0.0	0.0	77.5	100.0	116.0	412.3	390.0	293.5	164.1	21.1	134.1	47.1	1281.0	474.7	**1755.7**
3	Gandacherra	0.0	0.0	37.3	9.8	29.2	159.5	406.9	233.4	Station Not Responding				-	-	-
4	KVK Dhalai	0.0	6.7	43.2	107.2	112.4	384.6	419.4	319.5	226.3	154.7	130.6	51.2	1504.5	451.3	**1955.8**
2023	**DHALAI**	**0.0**	**1.7**	**67.1**	**78.2**	**99.6**	**373.1**	**383.2**	**281.4**	**195.8**	**101.1**	**116.4**	**49.1**	1334.6	412.0	**1746.6**

Year 2024:

Sl No	Stations	January	February	March	April	May	June	July	August	September	October	November	December	Monsoon	Non Monsoon	TOTAL
1	Kamalpur	0.0	65.2	51.1	27.0	666.7	618.4	382.0	807.8	232.8	292.8	25.6	12.3	2333.8	847.9	**3181.7**
2	Chawmanu	0.0	0.0	39.0	30.5	472.0	693.2	262.4	662.4	159.5	137.2	29.0	15.5	1914.7	586.0	**2500.7**
3	Gandacherra	0.0	0.0	56.9	12.0	756.8	676.8	385.2	157.1	67.1	122.1	5.2	9.6	1408.3	840.5	**2248.8**
4	KVK Dhalai	0.0	80.2	35.0	21.4	548.9	719.6	266.5	274.7	150.2	160.1	9.6	24.8	1571.1	719.9	**2291.0**
2024	**DHALAI**	**0.0**	**36.4**	**45.5**	**22.7**	**611.1**	**677.0**	**324.0**	**475.5**	**152.4**	**178.1**	**17.4**	**15.6**	1807.0	748.6	**2555.6**

Year 2025

Sl No	Stations	January	February	March	April	May	June	July	August	September	October	November	December	Monsoon	Non Monsoon	TOTAL
1	Kamalpur	0.0	32.5	40.3	-	-	-	-	-	-	-	-	-	-	-	-
2	Chawmanu	0.0	11.6	27.8	-	-	-	-	-	-	-	-	-	-	-	-
3	Gandacherra	0.0	12.3	39.5	-	-	-	-	-	-	-	-	-	-	-	-
4	KVK Dhalai	0.0	46.5	34.6	-	-	-	-	-	-	-	-	-	-	-	-
2025	**DHALAI**	**0.0**	**25.7**	**35.6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	**-**

11.6. DATASHEETS (Water Quality, Pre Monsoon, 2023):

Sl No.	Location	ID	Temp ^0C	pH	EC (µS/cm) at 25°C	Turbidity	TDS	CO_3	HCO_3	TA	Cl	SO_4^{2-}	NO_3^-	F^-	Ca^{++}	Mg^{++}	TH	Na	K	Br
						NTU	mg/ltr (ppm)													
BIS Water Quality Norms	Desirable		-	6.5-8.5	100	1	500	-	-	200	250	200	45	1.0	75	30	200	-	-	-
	Permissible		-	NR	2500	5	2000	-	-	600	1000	400	NR	1.5	200	100	600	-	-	-
1	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	23.1	8.01	130.00	BDL	84.50	0.00	73.26	73.26	7.09	3.94	0.59	0.01	12.01	4.85	50.00	11.94	1.83	0.00
2	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	24.6	8.08	102.40	0.10	66.56	0.00	67.15	67.15	7.09	1.56	0.62	0.01	6.00	4.85	35.00	8.98	2.51	0.00
3	Saya kumar Para Spring	TR/DH/05	22.5	7.77	50.10	0.11	32.57	0.00	36.63	36.63	7.09	0.83	1.30	0.00	6.00	1.21	20.00	8.44	1.20	0.00
4	Harincharra Spring - 1	TR/DH/06	27.6	7.65	64.20	0.09	41.73	0.00	54.94	54.94	3.54	2.09	0.44	0.00	6.00	3.64	30.00	7.76	1.94	0.00
5	Narsiraipara Spring	TR/DH/08	26.3	8.34	78.40	0.15	50.96	12.00	48.84	60.84	7.09	4.39	4.11	0.00	6.00	3.64	30.00	16.05	2.16	0.00
6	Nunacherra Spring	TR/DH/09	24.6	8.24	196.90	BDL	127.99	0.00	128.20	128.20	3.54	1.57	2.29	0.01	12.01	18.20	105.00	7.98	3.51	0.00
7	Parkaraipara Spring	TR/DH/10	13.8	7.83	129.80	BDL	84.37	0.00	24.42	24.42	21.27	2.17	9.07	0.00	12.01	3.63	45.00	10.57	2.21	0.00
8	GaganChaudhuryPara-1 Spring	TR/DH/11	24.9	7.90	108.30	BDL	70.40	0.00	97.68	97.68	7.09	1.87	2.72	0.00	8.01	9.70	60.00	16.79	1.29	0.00
9	GaganChaudhuryPara-2 Spring	TR/DH/12	26.4	7.99	226.00	0.12	146.90	0.00	85.47	85.47	21.27	15.48	9.04	0.00	30.02	4.84	95.00	18.17	1.63	0.00
10	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	23.4	8.07	110.20	0.18	71.63	0.00	79.36	79.36	7.09	3.23	5.44	0.01	8.01	8.49	55.00	6.71	5.04	0.00
11	Nutangram Spring	TR/DH/14	26.7	8.26	278.00	BDL	180.70	0.00	189.25	189.25	7.09	13.53	4.21	0.01	28.02	21.83	160.00	11.14	3.98	0.00
12	Thalcharra Spring (Small Outlet)	TR/DH/15	25.9	8.29	248.00	BDL	161.20	0.00	152.62	152.62	7.09	3.18	10.36	0.01	30.02	10.91	120.00	13.84	8.50	0.00
13	Udasinghpara Spring	TR/DH/16	27.3	8.24	163.20	0.09	106.08	0.00	122.10	122.10	10.64	1.35	4.22	0.01	14.01	10.92	80.00	10.17	1.15	0.00
14	Batapara Spring	TR/DH/17	23.9	8.15	98.40	0.13	63.96	0.00	91.57	91.57	3.55	1.31	2.38	0.00	10.01	3.64	40.00	18.88	1.80	0.00
15	Bachhamura Spring-1 (NH 208)	TR/DH/19	24.6	8.22	445.00	0.18	289.25	0.00	311.35	311.35	10.64	17.04	3.57	0.00	76.06	24.23	290.00	15.11	3.56	0.00
16	Harincharra Spring (Composite Discharge)	TR/DH/30	25.6	7.64	65.70	BDL	42.71	0.00	30.52	30.52	7.09	4.07	6.02	0.00	4.00	2.43	20.00	5.35	3.50	0.00

NR: No Relaxation, TA: Total Alkalinity, TH: Total Hardness

Sl No.	Location		ID	Fe	Zn	Mn	Ni	Cu	Al	As	Cr	Se	Cd	Hg	Pb	U
				mg/ltr (ppm)		µg/ltr (ppb)										
BIS Water Quality Norms		Acceptable		1.0	5	100	20	50	30	10	50	10	3	1	10	30
		Permissible		NR	15	300	NR	1500	200	NR	NR	NR	NR	NR	NR	NR
1	Kathalbari Spring 1 (Chandraipara)		TR/DH/02	6.075	BDL	412.685	BDL	BDL	7.491	1.458	BDL	BDL	BDL	0.031	BDL	0.016
2	Sindhu Kumar (SK) Para Spring (NH-8)		TR/DH/03	0.214	BDL	85.426	BDL	BDL	BDL	0.908	BDL	BDL	BDL	BDL	BDL	0.007
3	Saya kumar Para Spring		TR/DH/05	BDL	BDL	5.612	BDL	BDL	BDL	0.024	BDL	BDL	BDL	BDL	BDL	0.001
4	Harincharra Spring - 1		TR/DH/06	BDL	BDL	BDL	BDL	BDL	BDL	0.088	BDL	BDL	BDL	BDL	BDL	0.015
5	Narsiraipara Spring		TR/DH/08	0.174	BDL	37.952	BDL	BDL	25.974	0.944	BDL	BDL	BDL	BDL	BDL	0.028
6	Nunacherra Spring		TR/DH/09	0.065	BDL	37.742	BDL	BDL	BDL	0.179	BDL	BDL	BDL	BDL	BDL	0.010
7	Parkaraipara Spring		TR/DH/10	0.376	BDL	21.853	BDL	BDL	251.280	0.164	BDL	0.017	BDL	BDL	BDL	0.049
8	GaganChaudhuryPara-1 Spring		TR/DH/11	BDL	BDL	15.684	BDL	BDL	BDL	0.625	BDL	BDL	BDL	BDL	BDL	0.005
9	GaganChaudhuryPara-2 Spring		TR/DH/12	2.263	BDL	75.033	BDL	0.610	709.996	1.211	BDL	BDL	BDL	1.867	BDL	0.136
10	Chiching Charra Spring 1, Ratu Ruwaja Para		TR/DH/13	1.280	BDL	46.716	BDL	0.095	BDL	1.096	BDL	BDL	BDL	BDL	BDL	0.028
11	Nutangram Spring		TR/DH/14	4.441	BDL	1921.472	BDL	BDL	52.865	5.126	BDL	0.039	BDL	BDL	BDL	0.049
12	Thalcharra Spring (Small Outlet)		TR/DH/15	BDL	0.155	21.472	BDL	BDL	BDL	1.037	BDL	0.036	BDL	BDL	BDL	0.107
13	Udasinghpara Spring		TR/DH/16	BDL	BDL	BDL	BDL	BDL	BDL	0.067	BDL	BDL	BDL	BDL	BDL	0.114
14	Batapara Spring		TR/DH/17	0.306	BDL	8.349	BDL	BDL	85.478	0.133	BDL	BDL	BDL	BDL	BDL	0.024
15	Bachhamura Spring-1 (NH 208)		TR/DH/19	BDL	BDL	15.402	BDL	BDL	BDL	1.094	BDL	0.046	BDL	BDL	BDL	0.680
16	Harincharra Spring (Composite Discharge)		TR/DH/30	0.040	BDL	34.011	BDL	BDL	BDL	0.128	BDL	BDL	BDL	BDL	BDL	0.004

NR: No Relaxation, BDL: Below Detection Limit

11.7. DATASHEETS (Water Quality, Post Monsoon, 2023):

Sl No.	Location	ID	Temp ^0C	pH	EC (µS/cm) at 25°C	Turbidity	TDS	CO_3	HCO_3	TA	Cl	SO_4^{2-}	NO_3^-	F^-	Ca^{++}	Mg^{++}	TH	Na	K	Br
						NTU	mg/ltr (ppm)													
BIS Water Quality Norms	Desirable		-	6.5-8.5	100	1	500	-	-	200	250	200	45	1.0	75	30	200	-	-	-
	Permissible		-	NR	2500	5	2000	-	-	600	1000	400	NR	1.5	200	100	600	-	-	-
1	Krishnamanipara-1 Spring (NH-8)	TR/DH/01	23.6	7.11	239.00	BDL	155.35	0.00	146.52	146.52	17.73	7.85	0.00	0.51	34.03	10.91	130.00	22.34	7.11	0.00
2	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	25.3	6.97	125.20	BDL	81.38	0.00	79.36	79.36	14.18	6.21	11.67	0.20	12.01	3.63	45.00	28.00	6.39	0.00
3	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	24.3	7.23	70.40	BDL	45.76	0.00	42.73	42.73	14.18	1.25	0.57	0.34	4.00	1.21	15.00	21.20	5.99	0.00
4	Jogendrapara Spring (Mostly Dry)	TR/DH/04	23.6	7.20	362.10	BDL	235.37	0.00	195.36	195.36	24.82	12.88	0.30	0.00	26.02	23.04	159.97	36.14	9.10	0.00
5	Saya kumar Para Spring	TR/DH/05	21.6	7.31	52.87	BDL	34.37	0.00	42.73	42.73	17.73	2.01	0.25	0.03	8.01	1.21	25.00	18.58	5.76	0.00
6	Harincharra Spring - 1	TR/DH/06	25.7	6.56	59.00	BDL	38.35	0.00	54.94	54.94	17.73	1.06	0.52	0.10	8.01	1.21	25.00	23.20	6.84	0.00
7	Narsiraipara Spring	TR/DH/08	21.6	6.88	135.40	BDL	88.01	0.00	128.20	128.20	14.18	5.12	1.63	0.40	12.01	10.92	75.00	28.79	9.00	0.00
8	Nunacherra Spring	TR/DH/09	26	6.76	57.74	BDL	37.53	0.00	79.36	79.36	14.18	4.87	2.11	0.25	8.01	2.42	30.00	28.24	8.96	0.00
9	Parkaraipara Spring	TR/DH/10	25.1	6.97	106.70	BDL	69.36	0.00	67.15	67.15	21.27	3.22	11.28	0.10	12.01	2.42	40.00	30.66	6.09	0.00
10	GaganChaudhuryPara-1 Spring	TR/DH/11	24.1	7.20	91.79	BDL	59.66	0.00	108.31	108.31	14.18	2.17	1.47	0.28	14.01	2.42	45.00	33.57	6.45	0.00
11	GaganChaudhuryPara-2 Spring	TR/DH/12	24.6	7.18	257.60	BDL	167.44	0.00	158.73	158.73	46.09	6.24	29.50	0.40	28.02	8.48	105.00	68.26	9.91	0.00
12	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	22.9	6.97	67.30	BDL	43.75	0.00	54.94	54.94	14.18	3.16	0.43	0.26	10.01	1.21	30.00	18.31	6.62	0.00
13	Nutangram Spring	TR/DH/14	22.9	6.82	261.30	BDL	169.85	0.00	134.31	134.31	14.18	34.67	2.21	0.35	26.02	18.19	140.00	23.69	7.43	0.00
14	Udasinghpara Spring	TR/DH/16	28.2	7.80	231.40	BDL	150.41	0.00	195.36	195.36	17.73	3.40	3.66	0.27	22.02	20.62	140.00	34.24	12.86	0.00
15	Batapara Spring	TR/DH/17	27.6	6.91	87.89	BDL	57.13	0.00	97.68	97.68	17.73	4.13	0.57	0.30	12.01	1.21	35.00	37.61	8.82	0.00
16	Saikarbari Spring (NH 208)	TR/DH/18	24.5	7.25	497.40	BDL	323.31	0.00	195.36	195.36	14.18	33.14	0.61	0.46	50.04	14.52	184.93	4.77	2.08	0.00
17	Bachhamura Spring-1 (NH 208)	TR/DH/19	25.1	7.56	459.50	BDL	298.68	0.00	180.52	180.52	17.73	18.88	0.77	0.57	34.03	24.24	260.00	21.41	2.82	0.00

NR: No Relaxation, TA: Total Alkalinity, TH: Total Hardness

Sl No.	Location		ID	Fe	Zn	Mn	Ni	Cu	Al	As	Cr	Se	Cd	Hg	Pb	U
				mg/ltr (ppm)		µg/ltr (ppb)										
BIS Water Quality Norms		Acceptable		1.0	5	100	20	50	30	10	50	10	3	1	10	30
		Permissible		NR	15	300	NR	1500	200	NR	NR	NR	NR	NR	NR	NR
1	Krishnamanipara-1 Spring (NH-8)		TR/DH/01	BDL	0.010	BDL	0.758	BDL	2.828	0.711	BDL	0.070	BDL	0.031	BDL	0.458
2	Kathalbari Spring 1 (Chandraipara)		TR/DH/02	1.544	0.000	402.993	1.008	BDL	1.102	1.242	BDL	0.037	BDL	0.007	BDL	BDL
3	Sindhu Kumar (SK) Para Spring (NH-8)		TR/DH/03	0.091	0.001	21.955	0.778	BDL	4.640	0.326	BDL	0.021	BDL	0.014	BDL	BDL
4	Jogendrapara Spring (Mostly Dry)		TR/DH/04	0.087	0.003	35.709	0.498	BDL	13.988	0.572	BDL	0.010	BDL	0.015	0.066	0.634
5	Saya kumar Para Spring		TR/DH/05	BDL	0.002	BDL	0.530	BDL	1.554	0.036	BDL	0.037	0.005	0.009	BDL	BDL
6	Harincharra Spring - 1		TR/DH/06	0.013	0.011	10.173	4.772	0.435	0.316	0.145	2.682	0.506	0.032	0.031	0.116	0.021
7	Narsiraipara Spring		TR/DH/08	0.062	0.012	33.334	4.829	1.495	0.969	0.574	0.489	0.484	0.041	0.015	0.255	0.021
8	Nunacherra Spring		TR/DH/09	0.046	0.005	22.615	4.800	0.387	0.750	0.079	0.451	0.504	0.017	0.010	0.132	0.005
9	Parkaraipara Spring		TR/DH/10	0.022	0.005	5.350	5.945	0.365	0.555	0.051	1.658	0.547	0.014	0.025	0.092	0.011
10	GaganChaudhuryPara-1 Spring		TR/DH/11	0.015	0.010	17.664	6.975	0.475	0.594	0.201	1.145	0.440	0.018	0.013	0.122	0.006
11	GaganChaudhuryPara-2 Spring		TR/DH/12	0.012	0.008	26.888	4.460	0.402	0.240	0.137	0.395	0.435	0.022	0.018	0.059	0.010
12	Chiching Charra Spring 1, Ratu Ruwaja Para		TR/DH/13	0.272	0.002	BDL	1.113	BDL	3.372	0.294	BDL	0.048	BDL	0.027	BDL	BDL
13	Nutangram Spring		TR/DH/14	0.450	0.005	824.146	1.066	BDL	16.124	0.497	BDL	0.004	BDL	0.020	0.104	0.030
14	Udasinghpara Spring		TR/DH/16	0.196	0.006	246.574	5.222	0.412	2.283	0.924	0.323	0.459	0.016	0.013	0.349	0.169
15	Batapara Spring		TR/DH/17	0.014	0.010	7.643	4.604	0.755	0.389	0.186	7.151	0.488	0.014	0.012	0.091	0.009
16	Saikarbari Spring (NH 208)		TR/DH/18	0.051	0.011	97.394	4.597	0.245	0.372	0.477	0.288	0.565	0.011	0.015	0.062	0.499
17	Bachhamura Spring-1 (NH 208)		TR/DH/19	0.009	0.005	7.611	4.235	0.373	0.463	0.561	0.327	0.501	0.013	0.032	0.107	0.394

NR: No Relaxation, BDL: Below Detection Limit

11.8. DATASHEETS (Water Quality, Pre Monsoon, 2024):

Sl No.	Location	ID	Temp ^0C	pH	EC (µS/cm) at 25°C	Turbidity	TDS	CO_3	HCO_3	TA	Cl	SO_4^{2-}	NO_3^-	F^-	Ca^{++}	Mg^{++}	TH	Na	K	Br
						NTU	mg/ltr (ppm)													
BIS Water Quality Norms	Desirable		-	6.5-8.5	100	1	500	-	-	200	250	200	45	1.0	75	30	200	-	-	-
	Permissible		-	NR	2500	5	2000	-	-	600	1000	400	NR	1.5	200	100	600	-	-	-
1	45 Miles Springs (NH-8)	TR/KH/01	26	8.35	766.00	BDL	497.90	6.00	433.45	439.45	14.13	4.66	0.50	0.94	38.62	12.89	149.67	149.46	1.17	3.96
2	Krishnamanipara-1 Spring (NH-8)	TR/DH/01	27.5	7.47	290.10	0.30	188.57	0.00	189.25	189.25	0.84	9.12	0.25	0.19	37.97	20.02	189.92	10.65	2.74	4.06
3	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	24	6.74	124.10	BDL	80.67	0.00	91.57	91.57	0.48	1.97	0.30	0.13	19.71	4.84	69.21	11.57	1.28	3.87
4	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	24.5	7.02	92.20	BDL	59.93	0.00	79.36	79.36	1.25	2.51	0.22	0.12	15.47	4.77	58.32	8.45	1.60	3.87
5	Saya kumar Para Spring	TR/DH/05	26	7.11	120.00	BDL	78.00	0.00	79.36	79.36	2.10	2.20	4.10	0.04	17.60	3.01	56.38	5.61	13.69	3.06
6	Harincharra Spring	TR/DH/06	28	6.96	68.60	BDL	44.59	0.00	73.26	73.26	0.65	1.68	0.06	0.05	15.29	5.43	63.09	7.38	1.44	3.77
7	Bishwarampara Spring, Left small Cherra	TR/DH/07	27	8.32	337.00	0.10	219.05	6.00	122.10	128.10	2.61	14.56	0.23	0.16	3.00	23.22	222.78	13.68	4.83	3.72
8	Narsiraipara Spring	TR/DH/08	23	6.66	180.50	BDL	117.33	0.00	134.31	134.31	2.23	3.99	0.48	0.10	23.99	14.97	121.63	7.93	3.18	3.20
9	Nunacherra Spring	TR/DH/09	24	6.95	79.20	BDL	51.48	0.00	73.26	73.26	1.99	4.30	0.23	0.07	14.02	6.44	61.59	5.96	1.90	3.32
10	Parkaraipara Spring	TR/DH/10	29	7.00	120.30	BDL	78.20	0.00	91.57	91.57	6.86	2.01	0.60	0.06	17.54	7.66	75.40	10.75	1.02	3.07
11	GaganChaudhuryPara-1 Spring	TR/DH/11	29	6.72	95.40	BDL	62.01	0.00	91.57	91.57	1.75	1.36	0.10	0.04	23.30	4.71	77.65	7.53	0.79	2.93
12	GaganChaudhuryPara-2 Spring	TR/DH/12	24	6.65	251.00	BDL	163.15	0.00	79.36	79.36	21.48	14.64	30.67	0.11	27.14	14.27	126.66	17.92	1.81	2.99
13	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	26	7.10	90.00	BDL	58.50	0.00	79.36	79.36	1.22	0.54	0.31	0.09	15.93	6.50	66.60	5.31	3.33	3.26
14	Nutangram Spring	TR/DH/14	28	6.61	431.00	BDL	280.15	0.00	189.25	189.25	3.47	112.46	0.84	0.13	51.92	37.98	286.28	13.63	4.25	3.37
15	Thalcharra Spring (Small Outlet)	TR/DH/15	28	6.71	296.00	BDL	192.40	0.00	177.04	177.04	2.41	4.03	0.14	0.13	23.09	15.86	149.13	26.94	5.39	3.84
16	Udasinghpara Spring	TR/DH/16	26	6.94	163.50	BDL	106.28	0.00	97.68	97.68	2.24	0.73	0.19	0.09	5.00	12.99	113.71	10.41	1.02	3.44
17	Batapara Spring	TR/DH/17	27	7.08	104.70	BDL	68.06	0.00	73.26	73.26	1.74	1.03	1.47	0.05	17.04	3.74	60.52	9.24	1.72	3.19
18	Bachhamura Spring-1 (NH 208)	TR/DH/19	27	8.31	397.00	BDL	258.05	6.00	170.94	176.94	2.36	15.90	0.19	0.19	22.91	28.84	276.09	14.17	2.27	3.80
19	Chiching Charra Spring 2	TR/DH/20	26.3	6.92	95.50	0.20	62.08	0.00	67.15	67.15	0.86	4.98	0.08	0.12	13.34	6.48	62.55	6.58	2.03	3.44
20	Bachhamura-2 Spring	TR/DH/21	28.6	6.80	342.00	BDL	222.30	0.00	91.57	91.57	1.24	89.80	0.45	0.21	41.92	18.26	215.02	12.29	2.40	3.41
21	Kathalbari Spring 2	TR/DH/26	24	6.76	106.70	BDL	69.36	0.00	79.36	79.36	0.40	2.20	0.30	0.11	16.67	4.29	61.86	10.62	1.68	3.97
22	Krishnamanipara-2 Spring (NH-8)	TR/DH/28	27.3	6.69	172.40	BDL	112.06	0.00	140.41	140.41	0.62	1.15	0.12	0.17	26.18	12.64	117.51	8.91	2.79	3.23

NR: No Relaxation, TA: Total Alkalinity, TH: Total Hardness

Sl No.	Location		ID	Fe	Zn	Mn	Ni	Cu	Al	As	Cr	Se	Cd	Hg	Pb	U
				mg/ltr (ppm)		µg/ltr (ppb)										
BIS Water Quality Norms		Acceptable		1.0	5	100	20	50	30	10	50	10	3	1	10	30
		Permissible		NR	15	300	NR	1500	200	NR	NR	NR	NR	NR	NR	NR
1	43 Miles Springs (NH-8)		TR/KH/01	0.400	0.760	15.298	4.849	1.475	0.819	0.286	14.088	0.064	1.947	0.022	3.374	0.058
2	Krishnamanipara-1 Spring (NH-8)		TR/DH/01	0.273	0.286	60.797	3.188	0.613	0.254	0.186	2.965	0.043	0.745	0.003	1.287	0.024
3	Kathalbari Spring 1 (Chandraipara)		TR/DH/02	1.581	0.159	690.049	2.092	0.894	0.005	4.172	2.032	0.156	0.514	0.005	0.537	0.065
4	Sindhu Kumar (SK) Para Spring (NH-8)		TR/DH/03	0.028	0.384	21.663	1.504	0.317	BDL	0.202	3.323	BDL	0.273	BDL	1.826	0.042
5	Saya kumar Para Spring		TR/DH/05	0.106	0.130	38.564	1.091	0.321	0.036	0.284	1.766	0.021	0.400	0.010	0.476	0.017
6	Harincharra Spring		TR/DH/06	0.017	0.186	15.179	1.897	1.679	BDL	0.970	2.465	0.062	0.666	0.005	0.611	0.768
7	Bishwarampara Spring, Left small Cherra		TR/DH/07	0.467	0.349	76.403	4.738	0.495	0.025	0.678	3.185	0.094	0.865	0.012	1.566	0.025
8	Narsiraipara Spring		TR/DH/08	0.150	0.116	27.372	2.680	0.646	0.354	0.147	2.115	BDL	0.338	0.003	0.534	0.033
9	Nunacherra Spring		TR/DH/09	0.186	0.339	146.272	2.584	0.328	BDL	0.727	3.388	0.045	0.874	0.003	1.388	0.022
10	Parkaraipara Spring		TR/DH/10	3.556	0.191	434.039	3.292	0.256	0.040	1.575	1.994	0.034	0.548	0.001	0.736	0.020
11	GaganChaudhuryPara-1 Spring		TR/DH/11	0.035	0.126	36.662	1.850	0.912	0.140	0.079	0.104	0.054	0.022	0.014	0.125	0.003
12	GaganChaudhuryPara-2 Spring		TR/DH/12	6.816	0.179	543.969	3.416	0.377	0.123	1.263	1.894	0.037	0.563	0.007	0.905	0.018
13	Chiching Charra Spring 1, Ratu Ruwaja Para		TR/DH/13	1.103	0.645	246.222	3.167	1.246	0.217	0.189	0.015	0.995	0.055	0.078	1.067	0.019
14	Nutangram Spring		TR/DH/14	0.065	0.568	64.598	2.401	1.010	0.065	1.299	2.524	0.077	1.540	0.003	4.133	0.231
15	Thalcharra Spring (Small Outlet)		TR/DH/15	0.045	0.138	12.007	4.843	0.683	0.002	0.197	2.691	0.008	0.369	0.001	0.594	0.017
16	Udasinghpara Spring		TR/DH/16	0.096	0.357	6.493	4.910	0.797	0.170	0.155	6.079	0.129	0.847	0.000	1.678	0.131
17	Batapara Spring		TR/DH/17	0.618	0.251	46.049	3.049	0.607	0.110	0.713	2.763	0.051	0.794	0.020	1.945	0.021
18	Bachhamura Spring-1 (NH 208)		TR/DH/19	0.085	0.233	80.603	1.601	0.919	0.015	1.268	2.300	BDL	1.364	0.012	2.309	0.229
19	Chiching Charra Spring 2		TR/DH/20	0.891	0.325	59.101	9.505	110.874	0.646	3.252	0.076	0.068	0.163	0.015	14.991	0.558
20	Bachhamura-2 Spring		TR/DH/21	0.032	0.277	30.884	1.867	2.043	0.018	0.093	4.316	0.071	1.644	0.009	2.915	0.023
21	Kathalbari Spring 2		TR/DH/26	0.967	0.648	122.438	4.210	1.595	1.719	1.083	4.150	0.058	1.282	0.005	5.297	0.093
22	Krishnamanipara-2 Spring (NH-8)		TR/DH/28	0.050	0.245	2517.270	1.800	0.531	BDL	1.151	2.277	0.034	1.365	0.004	2.386	0.140

NR: No Relaxation, BDL: Below Detection Limit

11.9. DATASHEETS (Water Quality for Feasibility in Irrigation):

Sl No	Location of the Springs	ID	Pre Monsoon, 2023			Post Monsoon, 2023			Pre Monsoon, 2024		
			SAR	% Na	RSC	SAR	% Na	RSC	SAR	% Na	RSC
1	43 Miles Springs (NH-8)	TR/KH/01							5.31	68.26	4.31
2	Krishnamanipara-1 Spring (NH-8), Reang Para	TR/DH/01				0.85	25.89	-0.2	0.35	11.35	-0.44
3	Kathalbari Spring 1 (Chandraipara)	TR/DH/02	0.73	33.16	0.2	1.82	53.38	0.4	0.6	26.21	0.12
4	Sindhu Kumar (SK) Para Spring (NH-8)	TR/DH/03	0.66	33.83	0.4	2.38	67.04	0.4	0.48	23.34	0.14
5	Jogendrapara Spring (Mostly Dry)	TR/DH/04				1.24	31.42	0.01			
6	Saya kumar Para Spring	TR/DH/05				1.62	55.52	0.2	0.32	14.17	0.17
7	Harincharra Spring	TR/DH/06	0.62	34.2	0.3	2.02	59.92	0.4	0.41	20.44	-0.01
8	Bishwarampara Spring, Left small Cherra	TR/DH/07							0.59	21.4	0.14
9	Narsiraipara Spring	TR/DH/08	1.27	51.59	0.6	1.45	41.99	0.6	0.31	12.06	-0.23
10	Nunacherra Spring	TR/DH/09	0.34	13.69	0	2.24	59.7	0.7	0.33	16.83	-0.03
11	Parkaraipara Spring	TR/DH/10	0.69	32.46	-0.5	2.11	58.25	0.3	0.54	23.36	-0.01
12	GaganChaudhuryPara-1 Spring	TR/DH/11	0.94	37.21	0.4	2.18	57.82	0.88	0.37	17.23	-0.05
13	GaganChaudhuryPara-2 Spring	TR/DH/12	0.81	28.92	-0.5	2.9	55.78	0.5	0.69	23.21	-1.23
14	Chiching Charra Spring 1, Ratu Ruwaja Para	TR/DH/13	0.39	19.2	0.2	1.45	50.86	0.3	0.28	14.01	-0.03
15	Nutangram Spring	TR/DH/14	0.38	12.8	-0.1	0.87	25.63	-0.6	0.35	9.23	-2.62
16	Thalcharra Spring (Small Outlet)	TR/DH/15	0.55	18.7	0.1				1.06	31.07	0.44
17	Udasinghpara Spring	TR/DH/16	0.49	21.36	0.4	1.26	32.25	0.4	0.56	25.17	0.28
18	Batapara Spring	TR/DH/17	1.3	49.26	0.7	2.76	63.86	0.9	0.53	25.02	0.04
19	Saikarbari Spring (NH 208)	TR/DH/18				0.15	5.24	-0.49			
20	Bachhamura Spring-1 (NH 208)	TR/DH/19	0.39	10.04	-0.69	0.68	19.81	-0.74	0.46	14.69	-0.52
21	Chiching Charra Spring 2	TR/DH/20							0.37	18.59	-0.1
22	Bachhamura-2 Spring	TR/DH/21							0.4	12.74	-2.1
23	Kathalbari Spring 2	TR/DH/26							0.6	27.29	0.11
24	Krishnamanipara-2 Spring (NH-8)	TR/DH/28							0.36	13.8	-0.05
25	Harincharra Spring (Composite Discharge)	TR/DH/30	0.52	32.22	0.1						

11.10. LOCATION OF THE GEOPHYSICAL SITES AND THEIR DETAILS:

Sl. No.	VES	Village	Date	Latitude	Longitude	Stretch (m)	Remark
1	VES - 1	43 Miles	21/01/24	23.903956	91.750139	94	Along the Road
2	VES - 2	Krishnamanipara	21/01/24	23.884882	91.785813	120	Boder of Khowai & Dhalai DIst
3	VES - 3	Iladhan	22/01/24	23.902371	91.866552	200	
4	VES - 4	Iladhan – (Trans)	22/01/24	23.901508	91.866280	80	Transverse (N-S)
5	VES - 5	Harincherra (Hirankudna)	22/01/24	23.851464	91.880524	25	On top of the Spring, 5.2mtr
6	VES - 6	Gagan Choudhury Para	22/01/24	23.82844	91.888055	60	
7	VES - 7	Karnamanipara	23/01/24	23.818993	91.87941	55	
8	VES - 8	Jansen Bhawan	23/01/24	23.787044	91.852827	60	Jansen Bhawan
9	VES - 9	Boripara	23/01/24	23.680404	91.819289	94	
10	VES - 10	Ultacherra	23/01/24	23.636779	91.808506	212	
11	VES - 11	Kathalbari	24/01/24	23.920257	91.890386	100	Spring just 5 mtr below the VES Point
12	VES - 12	Sindhukumarpara	24/01/24	23.949746	91.962201	240	Along the Road
13	VES - 13	Bipramohan Karparipara	24/01/24	23.927691	91.993479	190	Durgacherra Well Nearby
14	VES - 14	Manu	24/01/24	23.985586	91.9937	145	Near Railway station
15	VES - 15	Basudevpur	25/01/24	23.959271	91.833507	500	331 Degree
16	VES - 16	Basudevpur-(Trans)	25/01/24	23.959271	91.833507	400	Tansverse, 225 degree
17	VES - 17	Abhanga	25/01/24	24.074127	91.831818	398	
18	VES - 18	Paschim Karnachhera	26/01/24	24.031179	92.000551	233	
19	VES - 19	Kormitwisa	26/01/24	24.048624	92.011569	235	
20	VES - 20	Rasnagar JB School (Kathalcherra)	26/01/24	24.09457	91.965351	227	
21	VES - 21	Musonli	26/01/24	24.084358	91.975968	300	

11.11. 90^0 V-NOTCH TABLE:

Height in mm	Q in LPS	Q in LPM	Q in m³/day		Height in mm	Q in LPS	Qin LPM	Q in m³/day
1	0.00005	0.00292	0.00421		51	0.83687	50.21249	72.30598
2	0.00027	0.01632	0.02349		52	0.87816	52.68973	75.87321
3	0.00074	0.04460	0.06422		53	0.92064	55.23850	79.54344
4	0.00152	0.09102	0.13107		54	0.96432	57.85944	83.31759
5	0.00264	0.15830	0.22795		55	1.00922	60.55321	87.19662
6	0.00415	0.24880	0.35827		56	1.05534	63.32045	91.18145
7	0.00608	0.36465	0.52510		57	1.10270	66.16180	95.27300
8	0.00846	0.50781	0.73125		58	1.15130	69.07790	99.47218
9	0.01133	0.68008	0.97931		59	1.20116	72.06936	103.77988
10	0.01472	0.88316	1.27175		60	1.25228	75.13682	108.19702
11	0.01864	1.11864	1.61085		61	1.30468	78.28088	112.72446
12	0.02313	1.38806	1.99880		62	1.35837	81.50215	117.36310
13	0.02821	1.69285	2.43770		63	1.41335	84.80125	122.11380
14	0.03391	2.03439	2.92953		64	1.46965	88.17877	126.97743
15	0.04023	2.41404	3.47621		65	1.52726	91.63530	131.95484
16	0.04722	2.83306	4.07960		66	1.58619	95.17144	137.04688
17	0.05488	3.29269	4.74148		67	1.64646	98.78778	142.25440
18	0.06324	3.79414	5.46356		68	1.70808	102.48488	147.57823
19	0.07231	4.33857	6.24754		69	1.77106	106.26334	153.01920
20	0.08212	4.92711	7.09504		70	1.83540	110.12371	158.57814
21	0.09268	5.56085	8.00763		71	1.90111	114.06658	164.25587
22	0.10401	6.24088	8.98687		72	1.96821	118.09249	170.05319
23	0.11614	6.96823	10.03426		73	2.03670	122.20202	175.97091
24	0.12907	7.74393	11.15126		74	2.10660	126.39572	182.00983
25	0.14282	8.56898	12.33933		75	2.17790	130.67413	188.17075
26	0.15741	9.44434	13.59985		76	2.25063	135.03782	194.45446
27	0.17285	10.37098	14.93421		77	2.32479	139.48731	200.86173
28	0.18916	11.34984	16.34376		78	2.40039	144.02315	207.39334
29	0.20636	12.38183	17.82983		79	2.47743	148.64588	214.05007
30	0.22446	13.46785	19.39371		80	2.55593	153.35603	220.83269
31	0.24348	14.60881	21.03668		81	2.63590	158.15413	227.74195
32	0.26343	15.80555	22.75999		82	2.71735	163.04071	234.77862
33	0.28432	17.05895	24.56489		83	2.80027	168.01628	241.94344
34	0.30616	18.36984	26.45257		84	2.88469	173.08137	249.23717
35	0.32898	19.73906	28.42425		85	2.97061	178.23650	256.66055
36	0.35279	21.16742	30.48108		86	3.05804	183.48217	264.21432
37	0.37760	22.65573	32.62424		87	3.14698	188.81889	271.89920
38	0.40341	24.20477	34.85487		88	3.23745	194.24718	279.71594
39	0.43026	25.81534	37.17410		89	3.32946	199.76754	287.66525
40	0.45814	27.48821	39.58302		90	3.42301	205.38046	295.74786
41	0.48707	29.22413	42.08275		91	3.51811	211.08645	303.96448
42	0.51706	31.02387	44.67437		92	3.61477	216.88600	312.31583
43	0.54814	32.88815	47.35894		93	3.71299	222.77960	320.80262
44	0.58030	34.81772	50.13752		94	3.81280	228.76774	329.42554
45	0.61355	36.81330	53.01115		95	3.91418	234.85091	338.18530
46	0.64793	38.87560	55.98087		96	4.01716	241.02959	347.08260
47	0.68342	41.00534	59.04769		97	4.12174	247.30426	356.11814
48	0.72005	43.20321	62.21262		98	4.22792	253.67541	365.29259
49	0.75783	45.46990	65.47665		99	4.33573	260.14350	374.60664
50	0.79677	47.80610	68.84078		100	4.44515	266.70902	384.06098

11.12. BIS 10500: 2012 STANDARD FOR DRINKING WATER (2nd Rev., Ammd. 1st June, 2015)

Essential Characteristics

Sr.no	Characteristic	Requirement (desirable)	Permissible limit in the absence of an alternative source
1.	Color-Hazen units, maximum	5	15
2.	Odour	Agreeable	Agreeable
3.	Taste	Agreeable	Agreeable
4.	Turbidity, NTU, Max	1	5
5.	pH value	6.5 to 8.5	No relaxation
6.	Total Dissolved Solids (TDS), mg/l, Max	500	2000
7.	Total Hardness (as $CaCO_3$), mg/l, Max,	200	600
8.	Total Alkalinity as ($CaCO_3$), mg/lit ,Max	200	600

Desirable Characteristics

9.	Aluminum (as Al), mg/lit, Max	0.03	0.2
10.	Ammonia (as total Ammonia-N), mg/lit, Max	0.5	No relaxation
11.	Anionic detergents (as MBAS), mg/lit, Max	0.2	1
12.	Arsenic (as As), mg/lit, Max	0.01	No relaxation
13.	Barium (as Ba), mg/lit, Max	0.7	No relaxation
14.	Boron (as B), mg/lit, Max	0.5	1
15.	Cadmium (as Cd), mg/lit, Max	0.003	No relaxation
16.	Calcium (as Ca), mg/l, Max	75	200
17.	Chlorides (as Cl), mg/l, Max	250	1000
18.	Chromium (as Cr), mg/lit, Max	0.05	No relaxation
19.	Copper (as Cu), mg/l, Max	0.05	1.5
20.	Cyanide (as Cn), mg/lit, Max	0.05	No relaxation
21.	Fluoride (as F), mg/l, Max	1	1.5
22.	Iron (as Fe), mg/l, Max	0.1	No relaxation
23.	Lead (as Pb), mg/lit, Max	0.01	No relaxation
24.	Magnesium (as Mg), mg/lit, Max	30	100
25.	Manganese (as Mn), mg/l, Max	0.1	0.3
26.	Mercury (as Hg), mg/lit, Max	0.001	No relaxation
27.	Mineral oil, mg/lit, Max	0.5	No relaxation
28.	Nitrate (as NO_3),mg/l, Max	45	No relaxation
29.	Pesticides, mg/lit, Max	Absent	0.001
30.	Phenolic compounds, mg/lit, Max	0.001	0.002
31.	Polynuclear Hydrocarbons (as PAH) mg/lit, Max	0.0001	No relaxation
32.	Polychlorinated biphenyls, mg/l, Max	0.0001	No relaxation
33.	Residual free Chlorine (as Cl), mg/l, Min	0.2	1
34.	Selenium (as Se), mg/lit, Max	0.01	No relaxation
35.	Silver (as Ag), mg/lit, Max	0.1	No relaxation
36.	Sulphate (as SO_4), mg/l, Max	200	400
37.	Sulphide (as H_2S), mg/l, Max	0.05	No relaxation
38.	Zinc (as Zn), mg/lit, Max	5	15
39.	Alpha emitters Bq/l, max	0.1	No relaxation
40.	Beta emitters Bq/l, max	1	No relaxation

Bacteriological Standards:

a) For water entering a distribution system- Coliform count in any sample of 100 ml should be zero (0).

b) For water in a distribution system – (i) Both E Coli & Total Coliform count in 100 ml of any sample must be zero (0).

11.13. LETTER OF APPRETIATION FROM THE STATE GOVERNMENT

अभिषेक सिंह, आई.ए.एस.
Abhishek Singh, IAS

सत्यमेव जयते

सचिव
लोक निर्माण विभाग (डीडब्ल्यूएस सहित),
बिजली विभाग, शहरी विकास विभाग,
त्रिपुरा सरकार
Secretary
Public Works Department
(including DWS), Urban
Development, Power Department
Government of Tripura

No.F.9(37)DIR/WSSO/DWS/

Dated, 29 .11.2023.

CERTIFICATE OF APPRECIATION

I take this opportunity to appreciate the Officers and Scientists of State Unit Office, Agartala, Central Ground Water Board for constantly supporting the Department of Public Works (Drinking Water and Sanitation), Government of Tripura in the forms of technical support and training.

The Source Sustainability Training (SST, held during 13th to 15th June, 2023) has an immense impact on the Officers of the Department. The meticulously planned field trip along with various power point presentations were excellent and easily grasped by our young officers.

With a very short notice & request, the State Unit Office, Agartala, CGWB planned an excellent Training Programme on Rain Water Harvesting (RWH) and Ground Water Recharge (GWR) structures (held during 9th and 10th October, 2023) for 120 odd officers from DWS, Government of Tripura. The office could manage additional resource persons from North Eastern Region Guwahati and SUO, Delhi. This training & the design provided has helped the Department in planning and construction of RWH / GWR structures across the State.

The Department of Public Works (Drinking Water and Sanitation) is indeed thankful to the officers from SUO Agartala, **Dr. Raja Ram Purohit, Sc-D & Smt. Ritu K. Oraon, Sc-C** for their exceptional support and coordination.

In future too, we look forward for customised training and support as and when required.

With thanks.

29/11/2023
(Abhishek Singh, IAS)

To

The Chairman,
Central Ground Water Board
Bhujal Bhawan, NH-IV
Faridabad, Haryana.

New Secretariat Building, Cpaital Complex, Agartala, Pin-799010, Tel : (0381) 241 -5706, 241-8070
E-mail: asingh.ias@nic.in/secypwd.tr2022@gmail.com

11.14. LETTER OF APPRETIATION FROM CML, TATA TRUST (an NGO)

Centre for Microfinance & Livelihood (CML)
An Initiative of **TATA TRUSTS**
5th Floor, Divine Plaza, Dispur Super Market, G.S Road, Guwahati - 781006, Assam
E-mail:admin@cmlnortheast.com, Tel: 0361-2229367

To, **Date: 13-02-2025**
Dr. Raja Ram Purohit
Scientist-D
Central Ground Water Board (CGWB)
State Unit Office, Agartala, Tripura

Subject: Expression of Gratitude for Support in Springshed Management Program in Dhalai & North Tripura

Respected Dr. Purohit,

I extend my sincere gratitude to you and the entire team at the Central Ground Water Board (CGWB), State Unit Office, Agartala, for your continuous and invaluable support towards the ongoing Springshed Management program being implemented by the Centre for Microfinance and Livelihood (CML) in Dhalai and North Tripura.

Your technical expertise, insights, and guidance have been instrumental in strengthening our efforts to enhance water security through the Integrated Springshed Management approach. The support provided by CGWB in hydrological assessments, technical recommendations, and knowledge-sharing sessions has significantly contributed to the scientific rigor of our interventions.

The collaboration with CGWB has helped us in identifying critical recharge areas, designing appropriate recharge structures, and building local capacities for sustainable groundwater management. Your unwavering commitment to addressing water scarcity challenges in the region aligns with our shared vision of community-driven, science-based solutions for water resource conservation.

With the encouraging response from stakeholders and communities, as well as the interest shown by the district administration in scaling up this initiative, we look forward to continued collaboration with CGWB. Your expertise will be crucial as we work towards expanding our interventions, strengthening community engagement, and ensuring the long-term sustainability of groundwater recharge mechanisms.

Once again, we truly appreciate your support and look forward to furthering our joint efforts in addressing water security challenges in Tripura.

With sincere regards,

Rituparno Chanda

Rituparno Chanda
Program Officer, WaSH, Assam & Tripura
Centre for Microfinance and Livelihood (CML)

Registered Office:
Rilum Foundation
Smit Village, Po.Smit, PS. Madanriting
Mawryngkneng Block, East Khasi Hills,
Dist: Meghalaya Pin - 793 015

www.cmlnortheast.com

Regional Office:
Tripura State Initiative- TATA TRUSTS
1st Floor, Das Gupta Villa, Near
North Side of Old Governor House,
Kunjaban, Agartala, West Tripura – 799006

11.15. SPRING INVENTORY DATA ENTRY FORM

Side | A

Spring Inventory Data Sheet for Individual Spring

Central Ground Water Board

Spring ID: ....

1. Organisation/Office: SUO Agartala, Central Ground Water Board
2. Annual Action Plan Year: 2023-24, Spring studies in Dhalai Dist of Tripura
3. Date & Time of the Inventory: ..../............../ 2023 Time: ....:............AM/PM
4. Spring ID being allotted: TR/DH/......................
5. Location Details:

State	District	Block / GP	Village	Spring Name
Tripura	Dhalai			

6. Geographical Coordinate:

Latitude	Longitude	Elevation (m amsl)	Approachability

Preferably in Degree Decimal

7. Type of Spring and Geology (also remarks if any):

----

8. Contact Person from a nearby resident:..,
   Mob:...................................... House No: ....
9. Distance from the nearby Habitat (in meters): .... If No habitat nearby, tick ☐
10. No of Household/Persons Dependent on the Spring: ....Household or .... Persons
11. Spring Water Use (Please Tick): ☐ Domestic, ☐ Irrigation, ☐ Community, ☐ Livestock
    ☐ Bottling Plant, ☐ Industries, ☐ Others
12. Any Alternate Source of Water in the nearby Area:...
13. Seasonality of Springs (please tick): ☐ Perennial, ☐ Seasonal. If Presently Dry, tick ☐
14. If Seasonal, tick the months of flow: ☐ Apr ☐ May ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec ☐ Jan ☐ Feb ☐ Mar
15. Variation in Discharge over the months: ☐ Yes/ ☐ No
16. Variation of Discharge over the Years: ☐ Yes/ ☐ No... If Yes, ☐ Increasing, ☐ Decreasing
17. Is it a Thermal Spring: ☐ Yes/ ☐ No

CGWB/SUO-AGT/RRP/ Spring ID:..............., Page No:............ Side: A

Spring Inventory Data Sheet for Individual Spring

Central Ground Water Board

Spring ID: ....

18. Any Colouration in the vicinity: like, ☐ Iron Stain (Dark Red), ☐ Sulphur Yellow

19. Basic Water Quality Parameters:

Colour	Turbidity (Y/N)	Smell (Sulphur/Amonia/Others)	Temp ^{0}C	pH	EC (μS/cm)

20. Cleanliness around the spring area: ☐ Clean/ ☐ Dirty

21. Collection Chamber or shed Present: ☐ Yes/ ☐ No, if present, Dimension:

Length...........mtr X Breadth............mtr X Depth ....mtr

CATCHMENT AREA:

22. Landuse Pattern in the spring Catchment Area (tick): ☐ Agriculture, ☐ Forest,

☐ Barren Land, ☐ Pasture, ☐ Industry, ☐ Any Other.................................

23. Spring Recharge area Land Ownership (tick): ☐ Community Land, ☐ Individual,

☐ Panchayat, ☐ Government, ☐ any Others.

24. If, Individual or Community, Land Owners Name of Recharge Area: ....,
....Mob:.. House No: ....

25. Is the Spring Vulnerable to Demolition (New Road or Industries):...

26. Discharge (Q) Measurement in Ltrs per Minute (LPM):

Month	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Date												
Q in lpm												

27. A small Sketch...

Spring	Spring-shed

Information Compiled By:.. Date: / /

CGWB/SUO-AGT/RRP/ Spring ID:..............., Page No:............ Side: B

भारत सरकार
Government of India
जल शक्ति मंत्रालय,
Ministry of Jal Shakti,
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
Department of Water Resources,
River Development and
Ganga Rejuvenation

केंद्रीय भूमि जल बोर्ड
Central Ground Water Board

NAQUIM 2.0

State Unit Office, Agartala

Tripura