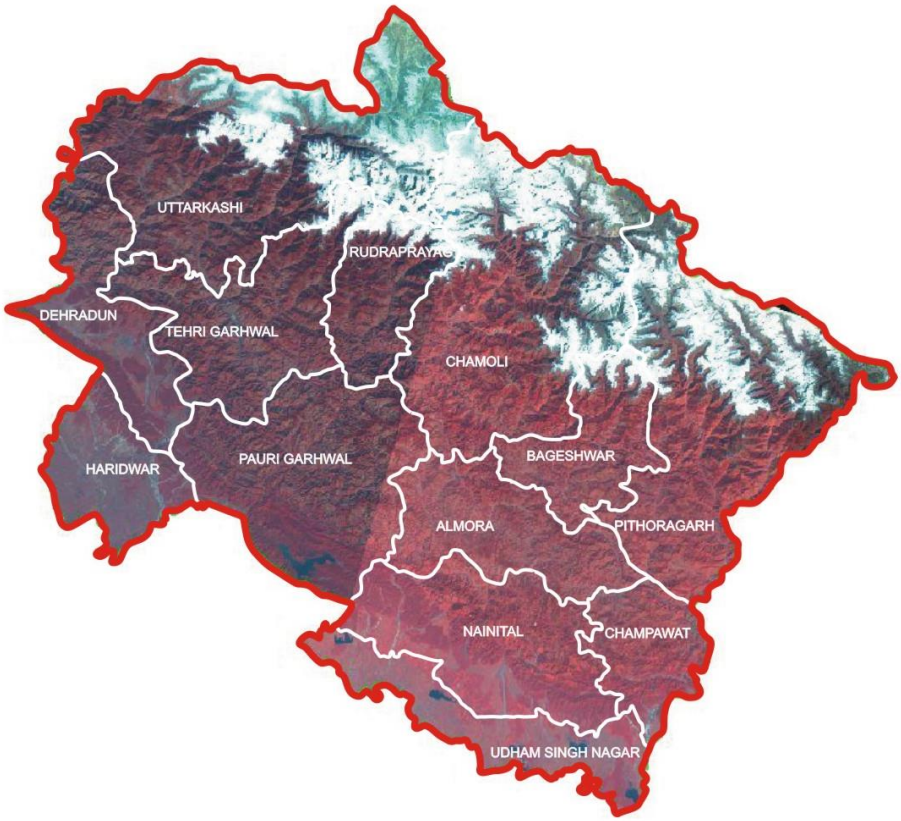
GROUND WATER YEAR BOOK 2017–2018

UTTARAKHAND

केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board



देहरादून
Dehra Dun

उत्तरांचल क्षेत्र
Uttaranchal Region

मार्च 2019
March 2019

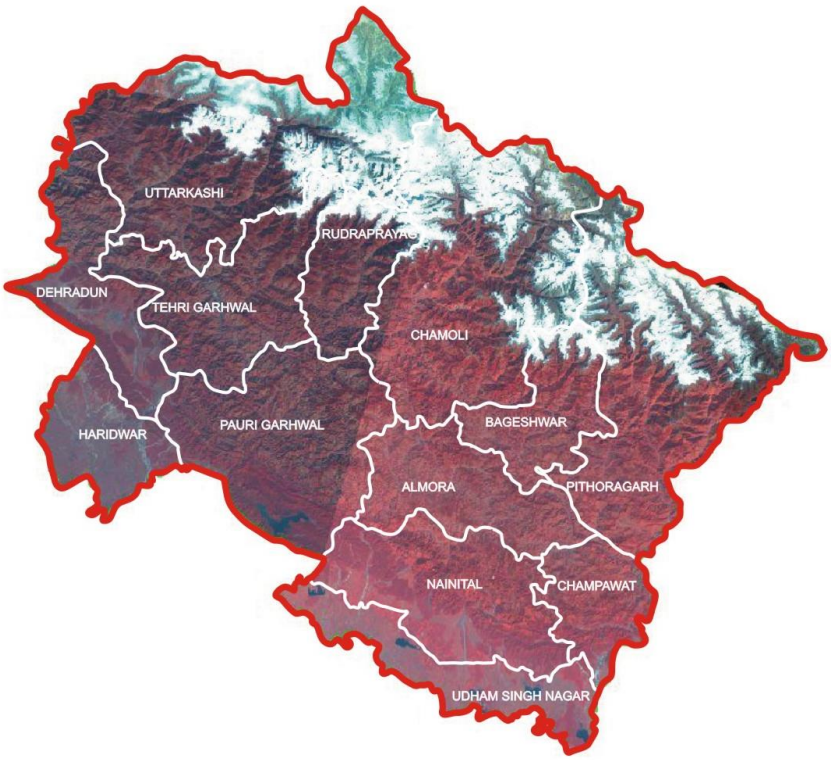
केन्द्रीय भूमि जल बोर्ड

Central Ground Water Board

GROUND WATER YEAR BOOK, 2017–2018
UTTARAKHAND

Contributor

Ms. Monalisha Singh, Scientist – 'B' (Jr. Hydrogeologist)



CENTRAL GROUND WATER BOARD
UTTARANCHAL REGION
DEHRA DUN
March 2019

FOREWORD

*WATER is one of the essential natural resources for sustaining life on blue planet "**Earth**". The demand of fresh / usable water has increased manifold globally due to rapid growth in population, which in turn caused change in agricultural pattern and increase in industrial activities. To meet the demand of fresh water of various sectors, there is an enormous stress on ground water resources as the surface water pollution is increasing day by day. This has resulted in the water level decline in many parts of the country as the output has outstripped input of this resource.*

*Ground water being a limited resource requires proper management and judicious use of its storage for meeting out demand on long term basis without putting any adverse impact on its regime. To meet this objective, Central Ground Water Board monitors the behaviour of ground water regime through a network of Ground Water Monitoring Wells spread across the country. The data collected from such wells in each state are compiled, processed and the salient features brought out as a "**Ground Water Year Book**". The present report pertains to the State of Uttarakhand for the year 2017 – 2018.*

Central Ground Water Board, Uttaranchal Region is monitoring the groundwater regime under various hydrogeological setting through 207 ground water monitoring wells in plain and hilly areas of Uttarakhand State, viz. Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora, Pauri Garhwal and Uttarkashi districts four times in a year (January, May, August and November). In the hilly areas of the State Thirty-seven springs are also being monitored.

The district wise details of ground water levels are presented along with thematic maps depicting the fluctuations for specific period of measurement as well as for the decade. The data has been stored in appropriate format in the data storage center of the Regional Office, Dehradun.

The present Ground Water Year Book, 2017 – 2018 is the outcome of the effort made by Ms. Monalisha Singh, Scientist- 'B' (Junior Hydrogeologist). The maps of the year book are prepared manually and then digitised. The efforts in depicting the groundwater scenario of Uttarakhand State through maps and giving proper shape to this report, is highly appreciable. The information and data presented in this report will serve as a database to the user agencies, ground water planners and managers and will be of immense use to understand the regional picture on the quantitative and qualitative aspects of ground water development in the State of Uttarakhand.

Place: Dehradun *Head of the Office*

GROUND WATER YEAR BOOK, UTTARAKHAND (2017 – 2018)

CONTENTS

TABLES

FIGURES

Annexures:

Executive Summary

The predominantly hilly Uttarakhand State was carved out of Uttar Pradesh in November 2000. The State comprises thirteen districts - Almora, Bageshwar, Chamoli, Champawat, Dehradun, Haridwar, Nainital, Pauri Garhwal, Pithoragarh, Tehri Garhwal, Rudraprayag, Udham Singh Nagar and Uttarkashi. The state is situated between latitude 28°43'20"N to 31°28'00"N and longitude 77°34'06"E to 81°01'31"E with a total geographical area of 53,483 km^2.

Uttarakhand State is broadly subdivided into two hydrogeomorphic units namely

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

Majority of area in the state falls under hilly terrain, except for Udham Singh Nagar, Haridwar and parts of Dehradun districts. Northern parts of the state remain under snow cover throughout the year. The drainage of the state is controlled by major rivers like Ganga (Gangotri) and Yamuna (Yamnotri), originating from the glaciers in high Himalayan Mountain Range and their tributaries like Ramganga, Kali, Saryu, Pindar etc. A variety of rock units ranging in age from Archean to Quaternary are exposed over the state. The rock units in the Himalayan mountain regions have undergone repeated phases of deformation and metamorphism after their formation.

In the plain areas, ground water occurs in multi aquifer systems. Perched water bodies lying above the main water bearing formations are frequently encountered in Bhabar Zone and Doon Valley. Contrary to this, the occurrence of ground water in the hilly areas is limited to small, localized aquifers with limited ground water potential. Ground water in hilly terrains is found in the secondary porosity developed in crystalline igneous and metamorphic rocks in the form of fractures, joints and fissures. Low to moderate ground water potential exists in parts of the state where ground water is located in valley fill deposits of the alluvial plains and piedmont zones. The chemical quality of ground water is generally good and the water can be safely used for drinking, domestic and irrigation purpose.

During the period May 2017 to January 2018, ground water monitoring in the state was carried out in parts of Dehradun, Haridwar, Udham Singh Nagar, Nainital, Champawat, Pauri Garhwal, Almora and Uttarkashi districts. A number of dug wells, hand pumps and few piezometers, which are the part of Ground Water Monitoring Wells of Central Ground Water Board, were monitored in the plain areas of these districts during the months of May, August and November 2017 and January 2018.

The depth to water level maps and water level fluctuation maps viz. decadal, annual and seasonal water level fluctuations were generated manually and then digitised by using coral draw software. These maps were prepared section wise viz. Dehradun Section, Haridwar section and Udham Singh Nagar-Nainital-Champawat section.

To assess the behaviour of ground water storage in space and time, the fluctuation in storage for each measurement has been evaluated with respect to decadal average value. A summary of depth to water level data in the State during the period May 2016 to January 2017 and the overall fluctuation pattern of ground water level (rise or decline) during the same period as compared to the long-term data (decadal average) are shown in tabular forms below. Moreover, annual fluctuation of water level (for the corresponding periods of May, August, November and January) and the fluctuation pattern of ground water level during the periods August 2016, November 2016 (post monsoon) and January 2017 as compared to May 2016 (pre monsoon) are also given in separate tables.

The status of water level fluctuation during each season/period with respect to observed data of pre-monsoon water level (May) during the same year indicated that decline in water level in the categories 0-2 m, 2-4 m and >4 m were significantly higher than the corresponding rise in the range of water level. The same situation was also observed for the annual water level fluctuation data also.

Summary of Depth to Water Data in Uttarakhand during the Period 2017 – 2018

State	**Range of depth to water level (m bgl)**	**Percentage of Wells Analyzed**			
		May 2017	**August 2017**	**November 2017**	**January 2018**
Uttarakhand	0–5	19.87	35.85	38.75	32.69
	5-10	29.80	26.42	23.75	21.15
	10-15	18.54	12.58	9.38	17.31
	>15	31.79	24.53	28.75	28.85

Fluctuation of Water Level during the Period 2017 – 2018 (Compared to Decadal Average)

State	**Fluctuation (m)**	**Percentage of Wells Analyzed**							
		Avg. May		Avg. August		Avg. November		Avg. January	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	27.19	36.84	29.57	33.91	38.97	36.76	29.58	41.55
	2–4	7.89	12.28	6.09	8.7	4.41	8.82	4.93	9.15
	>4	7.02	8.77	6.96	14.78	5.15	5.88	3.52	11.27

Annual Fluctuation of Water Level during the Period 2017 – 2018

State	Fluctuation (m)	Percentage of wells analyzed							
		May 2016 vs. 2017		August 2016 vs. 2017		November 2016 vs. 2017		January 2017 vs. 2018	
		Rise	Decline	Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	34.75	45.39	43.24	41.89	62.50	19.85	42.86	46.10
	2–4	5.67	5.67	6.08	4.05	3.68	2.21	2.60	2.60
	>4	2.13	6.38	2.03	2.70	8.82	2.94	3.25	2.60

Seasonal Fluctuation of Water Level (Compared to May 2017)

State	Fluctuation (m)	Percentage of wells analyzed					
		August 2017		November 2017		January 2018	
		Rise	Decline	Rise	Decline	Rise	Decline
Uttarakhand	0–2	8.9	30.14	56.76	12.16	64.79	18.31
	2–4	2.74	27.40	22.30	1.35	6.34	2.82
	>4	2.74	28.08	4.73	2.70	493	2.82

A perusal of various maps viz. depth to water level maps and water level fluctuation maps reveals that in general, many areas of Doon Valley (Dehradun district), parts of Haridwar district and Tarai Zone in Udham Singh Nagar district have shown both rise and decline in water levels of various magnitudes in different temporal aspects. Fluctuation in water level is more conspicuous in the Bhabar Zone in Nainital and Champawat districts than in the relatively plain areas of Central Ganga Plains in Haridwar district and in the Tarai zone in Udham Singh Nagar district. This Bhabar zone shows high ground water level fluctuation due to steep hydraulic gradient.

Chemical analysis of 406 ground water samples collected from Ground Water Monitoring Wells from parts of Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, Nainital, Champawat and Almora district is awaited at the Chemical Laboratory, Central Ground Water Board, North Region, Luckhnow. The water samples are to be analyzed for fourteen parameters viz. Electrical Conductivity (EC), pH, carbonate, bicarbonate, chloride, sulphate, nitrate, fluoride, calcium, magnesium, sodium, potassium, silica and Total Hardness (TH) as $CaCO_3$.

CHAPTER – 1
INTRODUCTION

Ground water is a very important component of Earth's natural fresh water resource. Hence, ground water regime monitoring on periodic basis becomes essential for a safe and sustainable development and management of ground water resources of the hilly state of Uttarakhand. The directly measurable and often visible physical parameter of the otherwise invisible ground water system is the ground water level. Regular and systematic monitoring of ground water levels and evaluation of chemical parameters of ground water forms the base for scientific planning, development and management programmes. Scientific information about the behaviour of water level in time and in space becomes an essential exercise in this perspective. Indiscriminate withdrawal of ground water in rapidly developing urban and industrial areas poses a challenge to the scientific community. The challenge can be overcome by adopting sustainable ground water development and management practices.

Uttarakhand State lies between 28°43'20" – 31°28'00" N Latitude and 77°34'06" – 81°01'31" E Longitude and has a total geographical area of 53,483 km^2. The state has been divided into two Divisions and thirteen developmental blocks. Uttarakhand has a diverse hydrogeological set up. In order to assess the impact of continuously increasing stress on the ground water regime and to categorize various hydrogeological units in the State, systematic monitoring of ground water levels and spring discharge are being carried out four times in a year by the Central Ground Water Board, Uttaranchal Region, Dehradun through the Ground Water Monitoring Stations, which included periodic measurement of Springs discharge in the hilly terrain.

As on March 2018, a total of two hundred and one ground water monitoring stations exist in Uttarakhand State, which are being monitored by the regional office four times in a year. The map showing locations of Ground Water Monitoring Wells and Springs in Dehradun, Haridwar, Nainital, Udham Singh Nagar, Champawat, Almora and Pauri Garhwal districts is shown as ***Fig. 1.***

Chemical analysis of water samples, collected from selected locations within the state once in a year during the month of May (pre-monsoon monitoring), is being carried out to check whether any significant change is taking place in groundwater quality in time and space.

The main objectives of ground water regime monitoring in Uttarakhand may be summarised as follows:

1. To study the fluctuation of water level, both spatially and temporally, in response to ground water recharge and/or discharge.
2. To evaluate changes in ground water level with respect to the preceding year for the same period.
3. To evaluate changes in ground water level with respect to a long term average water level such as the decadal mean.
4. To study the fluctuation of water level during different seasons of the period 2016 – 2017.
5. To study the hydrochemical behaviour of shallow aquifers.

The district wise break up of Ground Water Monitoring Stations (including the springs in hilly terrain), which were monitored during the period from May 2016 to January 2017 is given in ***Table 1.***

Table 1: District wise break up of active Ground Water Monitoring Stations (including Springs) monitored in Uttarakhand State

Sl. No.	*District*	*Number of Ground Water Monitoring Stations*			
		May 2017	*Aug 2017*	*Nov 2017*	*Jan 2018*
1.	Dehradun	52	52	52	52
2.	Haridwar	39	38	39	39
3.	Udham Singh Nagar	44	46	46	43
4.	Nainital	15	19	20	19
5.	Champawat	2	4	4	3
6.	Pauri Garhwal	1	1	1	1
7.	Almora	22	22	21	21
8.	Uttarkashi	12	12	12	12
TOTAL		**187**	**194**	**195**	**190**

Apart from the dug wells, hand pumps and piezometers, a total of thirty Seven springs in hilly areas of Uttarakhand were also monitored (as on January 2017). The details of these springs during the period May 2016 to January 2017 are given in ***Table 2.***

Table 2: District wise break up of Springs in Uttarakhand State

Sl. No.	*District*	*Number of Springs*			
		May 2017	*Aug 2017*	*Nov 2017*	*Jan 2018*
1.	Dehradun	3	3	3	3
2.	Nainital	7	7	7	6
3.	Almora	22	22	21	21
4.	Uttarkashi	4	4	4	4
TOTAL		**36**	**36**	**35**	**34**

The Ground Water Monitoring Stations (including Springs) have been further categorized on the basis of geological set up and catchments of the river basins in Uttarakhand. The relevant information in this regard is given in ***Table 3.***

Table 3: Geology and Basin wise breakup of the existing Ground Water Monitoring Stations in Uttarakhand State (as on January 2017)

River Basin/ Sub Basin	*Geology*	*Well No. & Location*
DEHRADUN DISTRICT		
Yamuna Basin, Tons Sub-basin	Doon Gravels (bouldery formation)	DDN-04 (Rampura), DDN-05 (Kuanwala), DDN-06 (Herbertpur), DDN-07 (Jhajra), DDN-08 (Lal Tappar), DDN-09 (Motichur), DDN-10 (Nanda ki Chowki), DDN-11 (Selaqui), DDN-18 (Kanwali), DDN-19 (Chhorba), DDN-20 (Shankarpur), DDN-21 (Judli), DDN-22 (Dandi), DDN-PZ1 (Chhorba), DDN-PZ2 (CGWB Office), DDN-HP-1 (Jhajra), DDN-HP-2 (Redapur), DDN-HP-3 (Majra), DDN-HP-4 (Bhaniawala), DDN-HP-5 (Balliwala), DDN-HP-6 (Harbanswala), DDN-HP-7 (TarlaNagal), DDN-HP-8 (Nanurkhera), DDN-HP-9 (Nanda Ki Chowki), DDN-HP-10 (Selaqui), DDN-HP-11 (Badripur), DDN-HP-12 (Baronwala), DDN-HP-13 (Kuanwala), DDN-HP-17 (Gularghati), DDN-HP-18 (Vikas Nagar), DDN-HP-19 (Khandgaon), DDN-HP-20 (Lal Tappar), DDN-HP-21 (Kotimaichak), DDN-HP-23 (KhadiriKhadakmap), DDN-HP-24 (Dudhli), DDN-HP-25 (Dakpatthar), DDN-HP-26 (Barothiwala), DDN-HP-27 (Dhakrani), DDN-HP-28 (Timli), DDN-HP-35 (Mathrowala), DDN-HP-33 (Telpura), DDN-HP-31 (Baronwala), DDN-32 (Baluwala), DDN-DW-30 (Haripur), DDN-HP-36 (Chandmari), DDN-DW-23 (Duggiawala), DDN-HP-37 (Chhorba), DDN-DW-13 (Dharmawal)
	Doon Gravels (bouldery formation) and Upper Siwaliks (conglomerate, pebbly sands, clay)	DDN-12 (Redapur), DDN-14A (Sabhawala), DDN-15 (Singhniwala), DDN-16 (Ramgarh), DDN-SP2 (Khandoli), DDN-HP16 (Maldeota), DDN-HP22 (Soda Sarauli), DDN-SP3 (Soda Sarauli), DDN-DW-16A(Ramgarh)
	Blaini – Krol, boulder beds	DDN-03 (Rishikesh), DDN-SP1 (Bhatta), DDN-HP-14 (Rishikesh), DDN-HP-15 (Purukulgaon)
HARIDWAR DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Tarai (gravel, sand and clay)	HRW-07 (Bahadrabad), HRW-08 (Missarpur), HRW-09 (Dhanpura), HRW-10 (Hussainpur), HRW-11 (Budhwa Shahid), HRW-12 (Shahidwala Grant), HRW-14 (Rathaura), HRW-15 (Sarai), HRW-16 (Librahedi), HRW-PZ1 (Roorkee), HRW-PZ2

		(Chudiala), HRW-HP-1 (Bhagwanpur), HRW-HP-2 (Bahabalpur), HRW-HP-3 (Jhabrera), HRW-HP-4 (Iqbalpur), HRW-HP-5 (Bugawala), HRW-HP-6 (ShahpurShitlakhera), HRW-HP-7 (Khanpur), HRW-HP-8 (Lakhnauta), HRW-HP-9 (Gurukul Narsen), HRW-HP-10 (Manglaur), HRW-HP-11 (Dallawala), HRW-HP-12 (Govardhanpur), HRW-HP-13 (Dhanpura), HRW-HP-14 (Bhikkampur), HRW-HP-15 (Bahadrabad), HRW-HP-16 (Chudiala), HRW-HP-17 (Shahidwala Grant), HRW-HP-18 (Imlikhera), HRW-HP-19 (Landhaura), HRW-HP-20 (Bhopatwala), HRW-HP-22 (Mudlana), HRW-HP-23 (Bhogpur), HRW-HP-24 (Sultanpur), HRW-HP-25(Kotamuradnagar), HRW-HP-26 (Laksar, HRW-HP-24 (Dudhadyalwala), HRW-HP-25 (Syampur), HRW-DW-16 (Teliwala), HRW-DW-17 (Sikhar), HRW-DW-18 (Kherajat), HRW-DW-19 (Nijampur), HRW-DW-20 (Ambkhera), HRW-DW-21 (Mohamadpur), HRW-DW-23 (Jaswawala), HRW-DW-24 (Kota Muradnagar)
	Siwaliks (sandstone, siltstone, conglomerate)	HRW-13 (Bandarjud), HRW-HP-21 (Laldhang)
UDHAM SINGH NAGAR DISTRICT		
Ganga basin, Ramganga Sub- basin	Tarai (gravel, sand and clay)	USN-01A (Kashipur), USN-02 (Khatima), USN-03 (Bazpur), USN-06A (Sitarganj), USN-07 (Bara), USN-08 (Beria Daulat), USN-09 (Jaspur), USN-11 (Angadpur), USN-12 (Patrampur), USN-13 (Bharatpur), USN-15 (BarkharePande), USN-18 (Banna Khera), USN-19 (Shantipuri), USN-20 (Nanak Mata), USN-21 (Chakarpur), USN-HP-1 (KamariaPakki), USN-HP-2 (Gangapur), USN-HP-3 (Bhagwanpur), USN-HP-4 (Beria Daulat), USN-HP-6 (Jogipura), USN-HP-9 (Majhola), USN-HP-10 (Dhanauri Patti), USN-HP-11 (Kalyanpur), USN-HP-12 (Patthar Chatta), USN-HP-13 (BarkharePande), USN-HP-14 (Sultanpur Patti), USN-HP-15 (Bharatpur), USN-HP-16 (Patrampur), USN-HP-18 (Sitarganj), USN-HP-19A (Kichha), USN-HP-20A (Durgapur), USN-HP-21 (Kopa Signal), USN-HP-22 (Chakarpur), USN-HP-23 (Jharkhandi), USN-HP-24 (Mahabir Nagar), USN-HP-25 (Sarasariya), USN-HP-26 (Rudrapur), USN-HP-28 (Missarwala), USN-HP-29 (Shankhera), USN-HP-30 (Kanaura), USN-HP-31 (Pritpur), USN-HP-32 (Badripur), USN-HP-33 (Pattharpui), USN-HP-34 (Badakhera), USN-HP-35 (Lalpuri), USN-HP-36 (Kanakpur), USN-HP-37 (Rajpura), USN-HP-38 (Pipiliya), USN-HP-39 (Begur Mod), USN-HP-40 (Bidora), USN-HP-41 (Dhyanpur), USN-HP-42 (Barianjaniya)

NAINITAL DISTRICT		
Ganga basin, Ramganga Sub- basin	Bhabar (boulders, gravel, sand and clay)	NTL-03 (Lalkuan), NTL-05 (Maldhan Colony), NTL-HP-1 (Ramnagar), NTL-HP-2 (Belparao), NTL-HP-3 (Dhela), NTL-HP-4 (PeeruMadara), NTL-HP-5 (Dhoniya), NTL-HP-6 (Lamachaur), NTL-HP-7 (Kaladhungi), NTL-HP-8 (Kathgodham), NTL-HP-9 (Sitapur), NTL-HP-10 (Khat Baas), NTL-HP-11 (Chilkiya), NTL-HP-12 (Chanda Devi Amratpur)
	Middle Siwaliks (sandstone with minor clay)	NTL04 (Garjiya), NTL-S1 (Dogaon), NTL-S3 (Garampani), NTL-S4 (Salari), NTL-S5 (Ranibagh), NTL-S6 (Jyolikote)
	Blaini-Krol, boulder beds	NTL-S2 (Sipahidhara), NTL-S7 (Kuda Ghat)
CHAMPAWAT DISTRICT		
Ganga basin, Ramganga Sub- basin	Bhabar (boulders, gravel, sand and clay)	CPT-01 (Tanakpur), CPT-HP-1 (Banbasa)
	Middle Siwaliks	CPT-HP-2 (Bastia), CPT-HP-3 (Bichayee)
	Lesser Himalaya	CPT-SP-1 (Lohaghat)
ALMORA DISTRICT		
Ganga basin, Ramganga Sub- basin	Almora – Ramgarh Formation	ALM-S-1 (PataliTalla), ALM-S-2 (PataliMalla), ALM-S-3 (Katarmal), ALM-S-4 (Dharanaula), ALM-S-5 (Palna), ALM-S-6 (Chinoda), ALM-S-7 (Guruda-I), ALM-S-8 (Guruda-II), ALM-S-9 (Dhansari), ALM-S-10 (Someshwar), ALM-S-11 (Dharanaula Zoo), ALM-S-12 (Bachuradi), ALM-S-13 (Deepakot), ALM-S-14 (Ramgath), ALM-S-15 (Bhagtola),ALM-S-16 (Itola), ALM-S-17 (Potasarain), ALM-S-18 ChhaniBartola), ALM-S-19 (Lodh), ALM-S-21 (Dhalnagaon), ALM-S-22 (Semalkhet), ALM-S-23 (Naula), ALM-S-24 (Bania Diggi)
PAURI GARHWAL DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Bhabar (boulders, gravel, sand and clay)	PG-HP-1 (Kaudiya)
UTTARKASHI DISTRICT		
Ganga Basin, Upper Ganga Sub-basin	Lesser Himalaya	UK-HP-1 (Chinyalisaur), UK-HP-2 (Devidhar), UK-HP-3 (Uttarkashi), UK-HP-4 (Barkot), UK-HP-5 (Sharukhet), UK-HP-6 (Ganeshpur), UK-HP-7 (Maneri), UK-SP-1 (Dharasu), UK-SP-2 (Nagal), UK-SP-3 (Ratodisar)

DEHRADUN DISTRICT

1. Rishikesh 2. Rampura 3. Kuanwala 4. Herbertpur 5. Motichur
6. Sabhawala 7. Singhniwala 8. Ramgarh 9. Kanwali 10. Chhorba
11. Shankarpur 12. Judli 13. Jhajra 14. Redapur 15. Majra 16. Bhaniawala
17. Balliwala 18. Harbanswala 19. Tarla Nagal 20. Nanurkhera
21. Chhorba Pz 22. Nanda Ki Chowki 23. Selaqui 24. Baronwala
25. Kuanwala 26. Rishikesh 27. Purukulgaon 28. Maldeota 29. Gularghati
30. Vikas Nagar 31. Khandgaon 32. Lal Tappar 33. Kotimaichak
34. Soda Sarauli 35. CGWB Office 36. Dandi 37. Khadakmap
38. Dudhli 39. Bhatta Sp 40. Khandoli Sp 41. Soda Sarauli Sp
42. Dakpatthar 43. Barothiwala 44. Dhakrani 45. Badripur 46. Timli

HARIDWAR DISTRICT

47. Bahadrabad 48. Dhanpura 49. Hussainpur 50. Roorkee
51. Bhagwanpur 52. Chudiala 53. Bahabalpur 54. Jhabrera
55. Iqbalpur 56. Bugawala 57. Shahidwala Grant 58. Bandarjud
59. Rathaura 60. Sarai 61. Shahpur Shitlakhera 62. Khanpur
63. Lakhnauta 64. Chudiala 65. Gurukul Narsan 66. Manglaur
67. Dallawala 68. Govardhanpur 69. Bhikkampur 70. Imlikhera
71. Landhaura 72. Bhopatwala 73. Laldhang

PAURI GARHWAL DISTRICT

74. Kaudiya

UDHAM SINGH NAGAR DISTRICT

75. Kashipur	76. Khatima	77. Bazpur
78. Kichha	79. Sitarganj	80. Bara
81. Beria Daulat	82. Jaspur	83. Chakarpur
84. Dhanauri Patti	85. Kalyanpur	86. Patthar Chatta
87. Angadpur	88. Patrampur	89. Bharatpur
90. Barkhare Pande	91. Barhini	92. Sultanpur Patti
93. Banna Khera	94. Shantipuri	95. Nanak Mata
96. Kamaria Pakki	97. Gangapur	98. Bhagwanpur
99. Mahabir Nagar	100. Jogipura	101. Jhagarpuri
102. Majhola	103. Jharkhandi	104. Tukri
105. Sarasariya	106. Durgapur	107. Kopa Signal
108. Rudrapur		

NAINITAL DISTRICT

110. Lalkuan 111. Garjia 112. Maldhan Colony 113. Ramnagar
114. Belparao 115. Dhela 116. Peeru Madara 117. Dohniya
118. Lamachaur 119. Kaladhungi 120. Kathgodham 121. Sitapur
122. Khat Baas 123. Dogaon 124. Sipahidhara 125. Garampani
126. Salari 127. Ranibagh 128. Jyolikote

CHAMPAWAT DISTRICT

129. Banbasa 130. Tanakpur 131. Bastia

ALMORA DISTRICT

132. Patli Talla 133. Patli Malla 134. Katarmal 135. Dharanaula
136. Dharanaula Zoo 137. Palna 138. Chinoda 139. Guruda-I
140. Guruda-II 141. Bachuradi 142. Someshwar 143. Dhansari
144. Deepakot 145. Ramgath 146. Bhagtola

UTTARKASHI DISTRICT

147. Chinyalisaur 148. Devidhar 149. Uttarkashi 150. Dharasu 151. Barkot
152. Sherukhet 153. Ganeshpur 154. Maneri 155. Nagal 156. Ratodi Sar

Figure 1 Location of Ground Water Monitoring Stations in Uttarakhand (As on March 2018)

CHAPTER – 2

CLIMATE

The hilly parts of Uttarakhand experience cold climate and high rainfall. Significantly large part of the state remains under snow cover throughout the year. The intermontane valleys and the plain area in the southern part of the state experience a sub tropical climate with three seasons – summer, monsoon and winter. The normal annual rainfall varies from 1256 mm in Haridwar district to 2426 mm in Pithoragarh district. The average annual rainfall varies from 927.7 mm at Joshimath (Chamoli district) to 2599.4 mm at Munsyari (Pithoragarh district). Most of the rainfall occurs as monsoon rainfall during the months of July and August. The Isohyetal Map of Uttarakhand prepared using mean normal rainfall is given in **Fig. 2**. The map reveals that intensity of rainfall increases from SW to NW in a broadly linear pattern with high rainfall prevailing in both the eastern and the western parts of the state. The district wise normal monthly and annual rainfall data, available for seventy years (1901 to 1970) is given in **Table 4.**

Table 4: District wise normal monthly and annual rainfall (mm) in Uttarakhand State (1901-1970)

District	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
Dehradun	57.4	55.8	37.6	17.1	34.0	178.9	686.9	751.5	314.5	47.1	7.8	37.4	2212.0
Chamoli	103.0	107.8	114.5	57.2	47.9	117.1	314.4	322.0	169.0	51.4	23.5	47.0	1474.8
Nainital	37.7	33.4	18.7	8.6	27.2	173.6	466.2	454.7	239.7	52.2	3.9	11.9	1527.8
Pithoragarh	257.8	193.4	190.9	78.2	70.9	239.4	496.7	441.8	290.9	57.2	32.4	76.3	2425.9
Haridwar	48.1	45.8	24.5	9.8	19.9	108.9	360.1	393.8	190.2	34.3	5.4	15.4	1256.2
Tehri Garhwal	64.1	50.5	57.5	25.9	47.0	120.7	374.3	339.8	207.2	62.5	10.6	34.5	1394.6
Uttarkashi	102.4	59.2	90.4	46.6	72.7	128.8	400.3	426.5	301.4	46.9	20.4	36.5	1732.1
Almora	54.8	56.5	49.8	32.4	56.8	162.4	345.5	321.5	165.5	56.0	7.5	21.6	1330.3
Pauri Garhwal	58.9	59.8	41.9	23.5	45.0	151.4	412.9	402.5	188.9	43.7	6.8	23.0	1458.4

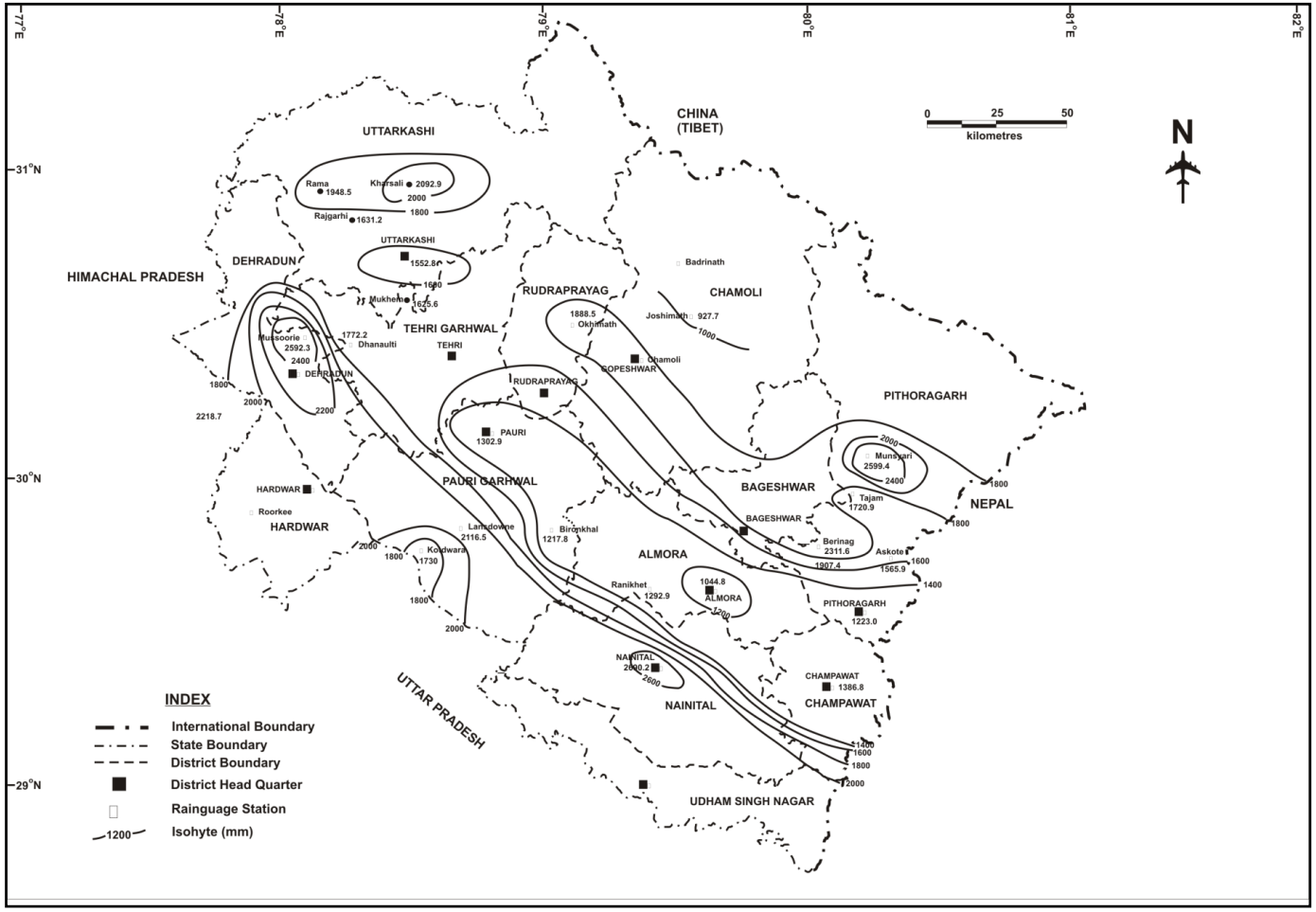


Figure 2 Mean Annual Isohyetal Map, Uttarakhand State

CHAPTER – 3

GEOLOGY

The state of Uttarakhand has distinct geological attributes with a wide spectrum of rock types ranging in age from Achaean to Quaternary. Based on the diversity of geological processes in time and space, the state can be subdivided into two major physiographic-cum-tectonic units, viz.

1) Gangetic Alluvial Plain
2) Himalayan Mountain Belt.

A brief description of the geology of Uttarakhand is given below.

1. Gangetic Alluvial Plain

Gangetic Alluvial Plain, a part of the Indo-Gangetic Foreland Basin, occupies the southernmost part of the state. This zone consists of Quaternary fluvial sediments also known as Ganga Alluvium. Subsurface investigations in this belt have revealed a thick pile of alluvium resting conformably over the Siwalik succession of Neogene to early Pleistocene Period. The thickness of alluvium increases towards north and attains its maximum adjacent to the *Foot Hill Fault* (FHF), which marks the northern limit of the youngest foreland basin in India i.e. the Ganga Fore deep Basin. The Ganga Fore deep sediments extend up to the south of depositional boundary of the Siwalik succession and rests over Precambrian cratonic rocks of Peninsular Indian Shield.

2. Himalayan Mountain Belt (Extra Peninsular Belt)

The Himalayan Mountain Belt is a part of the global mobile belt of Mesozoic to Cenozoic age that is believed to have evolved through the convergence of active Indian Plate and passive Eurasian Plate during the continent-continent lithospheric collision. Late Proterozoic (Neoproterozoic) to early Cenozoic crustal sequences form a small part of Himalaya, whereas the main mountain chain consisting predominantly of Proterozoic rocks represents a part of the Indian Shield. The Proterozoic crystalline rocks have been affected by various orogenic episodes of Mesozoic to Cenozoic Period and show signs of multiple phases of deformation and metamorphism. The Extra-Peninsular region has a wide spectrum of rocks of sedimentary, metamorphic and igneous origin.

Uttarakhand State is a part of Western Himalaya. Four distinct tectonic zones, each characterized by specific geological attributes and bounded by prominent dislocation zones can be recognized in Uttarakhand Himalaya from south to north. A brief description of the zones is given below:

2.1. Outer Himalaya or Sub Himalaya

This zone constitutes of a thick Cenozoic sedimentary pile ranging in age from Paleocene to Upper Pleistocene. Its northern and southern boundaries are delimited by the *Main Boundary Thrust* (MBT) and the *Foot Hill Fault* (FHF) also known as the *Main Frontal Thrust* (MFT), respectively. This zone consists predominantly of continental molasses sediments of Siwalik Group ranging in age from Middle Miocene to Upper Pleistocene. The Siwalik Group has been subdivided into the Lower Siwalik, Middle Siwalik and Upper Siwalik. The Lower Siwalik consists of fine to medium grained sandstone with clay, the Middle Siwalik is formed of medium grained sandstone with calcareous concretions and sandy clay and the Upper Siwalik consists predominantly of conglomerate with lenticular outcrops of sandstone and minor clay. The elevation of this

zone ranges from 250 to 800 m above mean sea level and width varies from 25 to 100 km. This zone is also characterized by a number of flat-floored structural valleys such as the *Doon Valley.*

2.2. Lesser Himalaya

The litho units lying between the Main Boundary Thrust (MBT) in the south and the *Main Central Thrust* (MCT) in the north are included under the Lesser Himalayan Zone, which has the greatest exposed width of about 80 km in the Garhwal and Kumaun regions of Uttarakhand. The rocks of this zone are overlain by crystalline thrust sheets in the form of large klippen masses occupying mostly the higher topographical levels of the mountain ranges. Regionally metamorphosed Proterozoic rocks emplaced by granites of variable ages along with weakly metamorphosed to unmetamorphosed sedimentary rocks (quartzites with interbedded volcanics, carbonates associated with slate, quartzite and shale) occur extensively in this zone. The granitoids are associated with volcano sedimentary sequence (Bhimtal Formation) and are emplaced along with the predominantly metamorphic and metasedimentary rocks of this zone, forming large-scale nappes like the Almora-Ramgarh nappe, Baijnath-Askot nappe and Garhwal nappe.

2.3. Central or Higher Himalaya

This zone consists of thick slabs of Proterozoic crystalline rocks, which thrust southward along the *Main Central Thrust* (MCT), over-riding the Lesser Himalayan Zone. This zone is a 10-15 km wide sequence of metamorphic rocks and granites. This zone represents the Proterozoic basement that has been reactivated due to crustal shortening during the continent-continent collision of the Himalayan Orogeny. The metamorphic rocks exposed in this zone show progressive regional metamorphism ranging from green schist facies to upper amphibolite facies. Both foliated and non-foliated granitoids are emplaced in different structural and tectonic levels within the regionally metamorphosed crystallines.

2.4. Tethys Himalaya

This zone is occupied by the thick sedimentary sequence ranging in age from Late Precambrian (Neoproterozoic) to Lower Eocene. Sediments of marine facies, characteristic of continental shelf to continental slope environments of the Tethys Sea regime, are the predominant litho types of this zone. In Uttarakhand, this zone is well exposed in the Zanskar Mountains and mountain ranges of Kumaun region. This zone is separated from the Central Crystallines by Dar-Martoli Fault, with the Lower Martoli Formation representing the base of Phanerozoic, which is broadly folded and faulted with several local thrusts. The rock sequence comprises phyllite, mica schist and quartzite with lenticular outcrops of limestone.

CHAPTER – 4

HYDROGEOLOGY

Uttarakhand State has a very diverse hydrogeological set-up. However, thishilly state can broadly be classified into two hydrogeological regimes namely Gangetic Alluvial Plain and Himalayan Mountain Belt. The description of these two types of hydrogeological-cum-physiographic units with further subdivisions is given below:

1. Gangetic Alluvial Plain

The Gangetic Alluvial Plain is a vast expanse of alluvium of Tertiary and Quaternary age. Alluvium is a generalized term for detrital unconsolidated sediments comprising predominantly of clay, silt, sand and gravels formed on river beds, flood plains, alluvial fans etc. This zone is very promising from the hydrogeological point of view having substantial water resource. This unit can be subdivided into three distinct hydrogeological regimes from south to north, viz. Axial Belt, Tarai and Bhabar.

1.1. Axial Belt

This unit, also called as the Alluvial Plains, is demarcated by the termination of alluvial fans that grade further down slope into vast alluvial plains. This zone is composed of a mixture of gravel, sand, silt and clay deposited in alternating layers. The aquifers present in this zone are of unconfined to confined nature. The area, in general, has good ground water resource potential but overexploitation of ground water reserve at places has resulted in the decline of water levels and needs implementation of artificial recharge methods. Drilling in this zone can be best accomplished by Rotary Drilling method having high drilling rate and hence, requiring less time for drilling.

1.2. Tarai

This is a generalised term for a sedimentary unit consisting of a mixture of gravel, sand and clay (sometimes also referred to as Tarai Formation). The boundary between Tarai and Bhabar is demarcated by the presence of springs forming a linear pattern, thus delineating a "spring line". Due to the highly porous and permeable nature of the constituting material of sedimentary origin, many potential aquifers having groundwater of good chemical quality exist in this area. Two types of aquifers can be found in this zone –

a) Unconfined Aquifers down to depths of 30 meters below ground level (m bgl) and
b) Confined Aquifers that occur at depths greater than 30 m bgl under very high hydrostatic pressure.

The tubewells are tapping these aquifers generally exhibit free flowing conditions with hydraulic head sometimes as high as 10 m agl and discharge of 5000 lpm.

1.3. Bhabar

A mixture of clastic material having different size fractions (e.g. boulder, pebble, gravel, sand, silt and clay) constitutes this unit, which is also referred to as Bhabar Formation. Bhabar zone is also a promising hydrogeological entity though the occurrence of ground water at deeper levels (generally greater than 100 m bgl) poses a

problem for ground water exploitation. Central Ground Water Board has constructed 28 deep tube wells (with discharge as high as 5540 lpm) by percussion drilling method in this zone of the state. Perched water bodies having smaller water resource potential are frequently encountered in this zone.

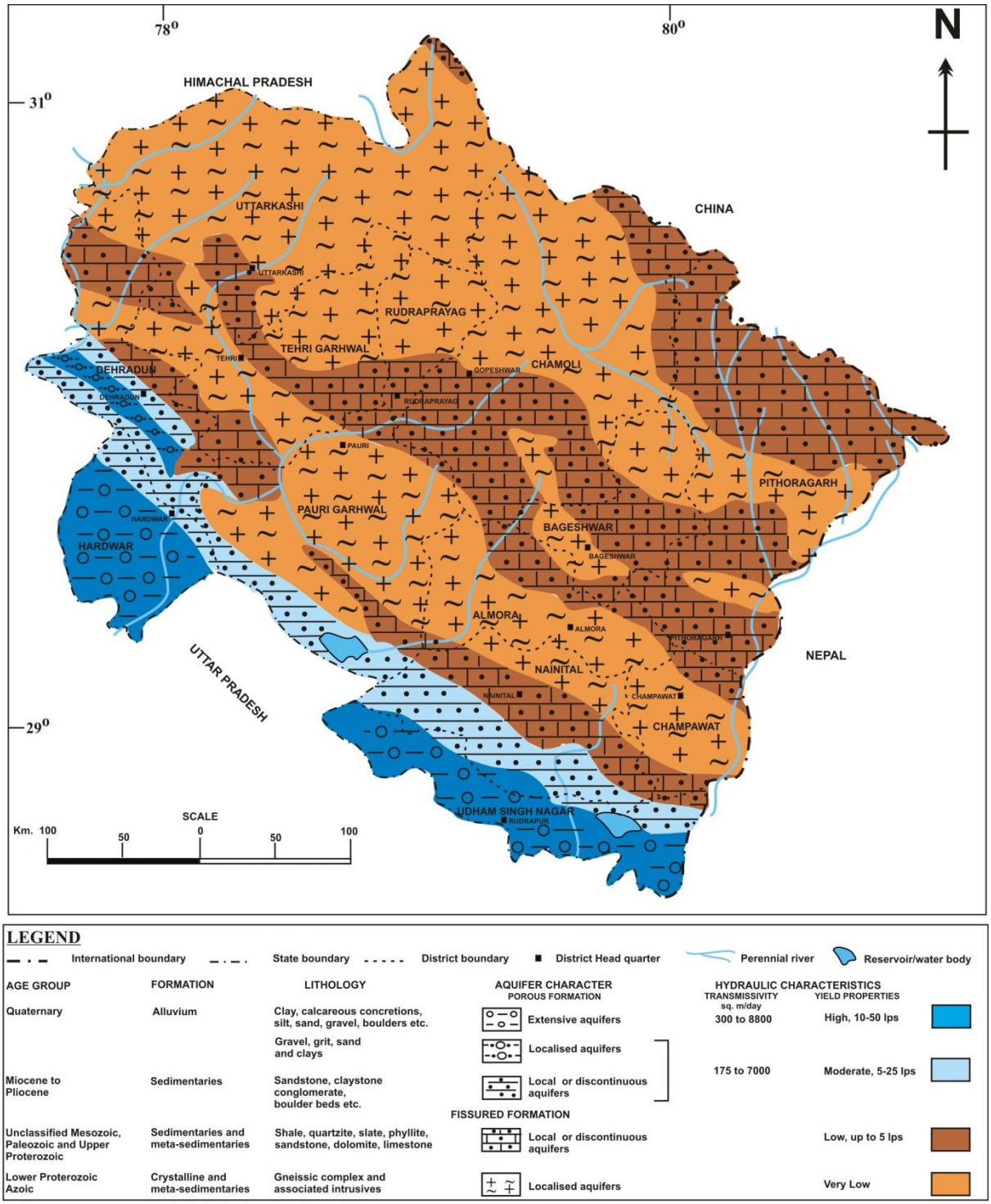


Figure 3 Hydrogeological Map of Uttarakhand

2. Himalayan Mountain Belt

This is a part of the Alpine-Himalayan Mountain Chain and constitutes a major part of the total geographical area of Uttarakhand. This zone is also known as Extra-Peninsular Region. The belt trends northwest – southeast with roughly parallel mountain ranges spanning across the state. This region can be further subdivided into five tectonic units from south to north. These units are Outer Himalaya, Lesser Himalaya, Central Himalaya, Tethyan Himalaya and Indus Suture Zone. However, the

Indus Suture Zone does not fall within the geographical area of Uttarakhand State. A brief description of the remaining four units that falls in the state is as follows:

2.1. Outer Himalaya (Siwalik Mountain Range)

This unit is composed dominantly of sandstone, ferruginous shale and clay and is younger in age as compared to the other units of the belt. The general elevation of the zone is less than 1000 m above mean sea level. Due to the semi-consolidated nature of rocks, potential ground water bearing formations are present in areas, which have a good weathered mantle and highly fractured/jointed rocks. In the Siwaliks, a number of valleys have also been developed as a result of tectonic activities (e. g. Doon Valley), which are very important from the hydrogeological point of view. The Doon Valley was formed as an *Intermontane Valley* within the Siwalik Group of rocks in a foreland propagating thrust system. The Lower, Middle and Upper Siwaliks are exposed in the area, and the Doon Gravels, a post-Siwalik Formation, were deposited with the evolution of the valley. The Doon Gravels are thickly bedded coarse clastic fan deposit of late Pleistocene and Holocene age. The Central Ground Water Board has successfully constructed 11 deep tubewells, with discharge ranging from 252 to 3197 lpm in the Doon Valley of Dehradun district. The water levels in these aquifers range from 20 m bgl in the southern part of the valley to about 100 m bgl in the northern part.

2.2. Lesser Himalaya

This zone is represented by mountains bounded by Main Boundary Thrust (MBT) in the south and Main Central Thrust (MCT) in the north having an elevation ranging between 1000 and 3000 m above mean sea level. This unit is dominantly composed of metasedimentary rocks and minor plutonic intrusives (granitoids). Springs form the most important source of ground water in this zone. In these formations ground water occurrence is restricted to the weathered residuum and the highly fractured/jointed zones of the area. Several hand pumps have been installed successfully in this zone. At a few places, especially in the river valleys, tubewells having low to moderate discharges have also been successfully constructed.

2.3. Central Himalaya

The Central Himalayan zone lies to the north of *Main Central Thrust* (MCT) with an elevation ranging from 5000 to 8000 m above mean sea level. Both cold water and hot water (thermal) springs are present in this zone. So far a total of 25 thermal springs have been investigated with temperatures ranging from 32°C to 70°C and discharge varying between 60 to 600 lpm, corresponding to 5^{th} order and 4^{th} order as per Meinzer's Classification of spring discharge. Due to highly inaccessible, snow-covered areas in this zone and a very steep hydraulic gradient, the possibility of ground water development is almost negligible.

2.4. Tethys Himalaya

Situated to the north of Central Himalayan zone, this zone is predominantly occupied by the highly fossiliferous sedimentary rocks ranging in age from Precambrian to Jurassic. Due to the porous and permeable nature of the litho units, this zone is generally suitable for ground water development.

CHAPTER – 5

BEHAVIOUR OF WATER LEVEL AND SPRING DISCHARGE

The water levels and spring discharge of Ground Water Monitoring Wells of Uttarakhand were measured four times during the period 2017-2018 (May, August, November 2017 and January 2018) as shown in Table 5. The ground water levels in different seasons were analyzed to evaluate the temporal behaviour of water level. The behaviour of water levels in each season during the period May 2017 – January 2018 has been compared with the water levels of previous year as well as with average water level for the last decade to ascertain the changes in ground water regime.

Apart from this, the fluctuation of water levels during the current year and previous year has also been evaluated in order to assess the adverse impact on hydrogeological regime, if any.

Table 5: Monitoring data of Ground Water Monitoring Wells, Uttarakhand State

Sl No.	*District*	*Block*	*Location Details*	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	Dehradun	*Doiwala*	Khandgaon	Hand Pump	9.4	8.97	8.8	4.83
2			Khadiri (Khadak Maf)	Hand Pump	13.79	14.12	8.74	13.64
3			Rishikesh	Hand Pump	7.89	13.31	8.32	5.14
4			Lal Tappar	Hand Pump	13.81	15.03	10.84	13.33
5			Dandi	Hand Pump	3.55	4.86	1.95	5.63
6			Bhaniawala	Hand Pump	32.3	30.28	26.29	25.94
7			Kotimachak	Hand Pump	20.39	20.01	9.32	18.67
8			Chandmari	Hand Pump	32.66	31.3	27.90	26.88
9			Duggiawala	Dug Well	2.52	1.56	0.46	1.26
10			Mathrowala	Hand Pump	12.41	11.37	7.98	8.8
11		*Raipur*	Kuanwala	Hand Pump	12.14	11.61	10.54	5.92
12			Gularghagti	Hand Pump	13.33	13.13	7.88	10.58
13			Balliwala	Hand Pump	56.27	59.35	55.34	54.69
14			Maldeota	Hand Pump	14.07	13.35	8.21	9.05

15			Nanurkhera	Hand Pump	59.33	59.52	56.60	60.67
17			Tarla Nagal	Piezom eter	84.25	77.95	71.91	78.65
18			Tarla Nagal	Hand Pump	46.63	53.47	50.34	54.9
19			Purukulgaon	Hand Pump	25.14	24.58	18.43	23.12
20			Majra	Hand Pump	9.34	13.13	11.65	6.35
21			CGWB Office	Piezom eter	56.8	61.21	61.56	53.85
22			Harbanswala	Hand Pump	47.13	60.75	55.39	54.23
23			Kanwali	Dug Well	13.55	12.3	9.10	12.29
24		*Sahaspur*	Singhniwala	Dug Well	8.36	9.1	8.54	8.98
25			Ramgarh	Dug Well	6.09	5.4	3.42	4.9
26			Jhajra	Hand Pump	12.74	12.5	7.17	9.1
27			Jhajra	Dug Well	14.14	15.08	6.94	9.45
28			Nanda ki Chowki	Dug Well	14.56	17.1	8.65	8.2
29			Nanda ki Chowki	Hand Pump	14.86	15.8	9.84	8.46
30			Selakui	Dug Well	9.91	9.91	8.85	9.04
32			Selakui	Hand Pump	10.79	12.37	9.40	9.65
33			Sabhawala	Dug Well	8.89	8.57	6.90	8.19
34			Rampura	Dug Well	9.31	9.65	7.73	9.6
35			Shankarpur	Dug Well	23.78	24.07	24.00	21.06
36			Redapur	Hand Pump	7.62	8.4	6.99	5.85
37			Redapur	Dug Well	5.76	6.94	5.85	4.44
38			Chhorba	Hand Pump	31	34.46	32.36	30.09
39			Telpura	Hand Pump	36.02	38.62	37.64	33.28
40		*Vikas Nagar*	Badripur	Hand Pump	8.81	11.89	8.19	8.63

41			Judli	Dug Well	13.54	12.91	12.08	13.11
42			Herbertpur	Dug Well	10.26	10.35	7.19	9.2
43			Vikas Nagar	Hand Pump	27.75	27.85	22.74	25.34
44			Dharmawala	Dug Well	3.65	5.53	3.64	3.7
45			Dakpatthar	Hand Pump	25.13	27.07	22.49	24.68
46			Dhakrani	Hand Pump	13.82	22.15	8.45	11.66
47			Timli	Hand Pump	66.35	61.85	57.32	58.72
48			Baluwala	Hand Pump	37.69	39.5	37.82	34.74
49			Luxmipur	Hand Pump	29.55	29.89	26.66	26.98
50			Haripur	Hand Pump	10.55	12.03	7.14	10.15
51			Ladpur Pz *	Piezometer	91.05	92.55	83.94	84.09
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	*Haridwar*	*Bhagwanpur*	Shahidwala Grant	Dug Well	10.11	11.87	10.8	9.53
2			Sahidwala Grant	Hand Pump	10.98	11.18	10.17	9.02
3			Budhwa Shahid	Dug Well	3.26	4.73	3.8	2.8
4			Bugawala	Hand Pump	6.4	8.55	6.38	3.11
5			Bahabalpur	Hand Pump	2.14	3.36	1.07	1.73
6			Bhagwanpur	Hand Pump	20.9	12.12	23.73	18.93
7			Chudiala	Hand Pump	21.59	25.78	21.83	21.05
8			Iqbalpur	Hand Pump	14.72	19.79	14.81	15.53
9			Jaswawala	Dug Well	3.62	4.6	2.93	3.16
10			Kota Muradnagar	Hand Pump	10.35	6.46	8.89	9.04
11		*Bahadrabad*	Bandarjud	Dug Well	9.36	10.61	8.73	7.44
12			Rathora	Dug Well	4.1	5.91	4.39	3.55

13			Bahadrabad	Hand Pump	12.04	10.19	12.2	11.27
14			Sarai	Dug Well	12.92	13.95	12.33	11.67
15			Dhanpura	Hand Pump	6.69	10.28	5.3	5.66
16			Shahpur Shitlakhera	Hand Pump	3.67	5.06	2.63	2.75
17			Laldhang	Hand Pump	57.19	67.57	66.46	57.42
18			Bhogpur	Hand Pump	2.85	4.82	1.61	2.91
19			Dalupuri	Dug Well	25.97	28.92	28.54	24.99
20			Panjaheri	Hand Pump	6.93	7.68	3.8	6.6
21			Dudhya Dayalwala	Hand Pump	3.11	3.69	2.51	2.76
22			Shyampur	Hand Pump	7.72	9.42	9.4	9.46
23		*Roorkee*	Imlikhera	Hand Pump	12.34	18.75	20.91	17.13
24			Roorkee	Piezom eter	5.75	8.24	6.17	5.95
25			Sikhar	Dug Well	16.68	18.07	17.66	16.43
26			Khera Jat	Dug Well	5.75	7.02	6.13	6.8
27			Nizampur	Dug Well	10.28	11.12	11.26	10.14
28		*Narsan*	Jhabreda	Hand Pump	10.45	9.8	11.11	11.64
29			Landhaura	Hand Pump	17.95	18.12	19.99	18.35
30			Lakhnauta	Hand Pump	7.19	9.41	6.95	6.87
31			Gurukul Narsen	Hand Pump	5.32	6.3	4.76	4.9
32			Libhrahedi	Dug Well	6.22	7.95	5.94	5.98
33			Mudlana	Hand Pump	17.76	16.12	17.44	16.3
34		*Laksar*	Hussainpur	Dug Well	0.83	3.81	0.93	1.86
35			Laksar	Hand Pump	2.62	3.65	2.01	2.51
36			Bhikkampur	Hand Pump	2.39	2.98	1.83	1.9

37		*Khanpur*	Govardhanpur	Hand Pump	2.5	4.11	1.37	2.87
38			Dallawala	Hand Pump	1.54	1.78	NA	1.47
39			Khanpur	Hand Pump	3.07	4.11	1.37	2.87
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	Nainital	*Haldwani*	Khaat Baans	Hand Pump	33.28	8.5	32.4	29.8
2			Lalkuan	Dug Well	5.21	NA	10.81	9.41
3			Lamachaur	Hand Pump	44.27	NA	52.86	46.56
4			Kaladungi	Hand Pump	31.6	34.4	26.6	27
5			Kathgodam	Hand Pump	20.56	19.86	14.56	16.96
6		*Ramnagar*	Belparao	Hand Pump	54.96	NA	54.26	53.68
7			Peeru Madara	Hand Pump	22.8	43	23.54	21.04
8			Maldhan Colony	Dug Well	3.64	NA	3.08	2.78
9			Dhela	Hand Pump	68.18	79.98	NA	72.58
10			Ram Nagar	Hand Pump	8.43	NA	4.13	6.16
11			Garjiya	Dug Well	4.5	5.1	3.1	4
12			Dohniya	Hand Pump	59.28	78.88	28.48	51.18
13			Chilkiya	Hand Pump	50.32	69.78	33.38	51.08
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	Udham Singh Nagar	*Khatima*	Kanchanpur (Majhola) HP	Hand Pump	4.35	5.5	2.4	3.87
2			Khatima	Dug Well	2.42	3.55	1	1.71
3			Sarasariya	Hand Pump	2.65	3.98	4.45	4.51
4			Chakarpur	Hand Pump	NA	7.1	4.57	3.48
5			Barianjaniya	Hand Pump	4.23	5.9	1.35	3.21

6		*Sitarganj*	Sitarganj	Hand Pump	1.93	3.64	0.44	1.19
7			Nanak Mata	Dug Well	2.81	8.87	3.19	2.11
8			Kalyanpur	Hand Pump	2.52	NA	0.76	1.14
9			Tukri	Hand Pump	3.85	0.19	1.06	2.12
10			Begur Mod	Hand Pump	3.7	6.06	1.21	1.18
11			Bidora	Hand Pump	NA	5.17	1.01	2.13
12			Dhyanpur	Hand Pump	2.32	6	1.1	0.67
13		*Rudrapur*	Bara	Dug Well	3.02	1.25	0.55	1.6
14			Kichha	Hand Pump	6.47	6.22	10.77	8.15
15			Kamaria Pakki	Hand Pump	5.67	6.67	3.92	3.54
16			Gangapur	Hand Pump	2.66	4.7	2.1	2.44
17			Shantipuri	Dug Well	1.79	2.23	0.58	1.93
18			Patthar Chatta	Hand Pump	2.48	3.86	2.36	3.07
19			Rudrapur	Hand Pump	2.21	2.7	1.4	3.78
20			Kanakpur	Hand Pump	2.52	4.89	3.49	2.46
21			Rajpura	Hand Pump	6.39	NA	3.03	1.38
22			Pipaliya	Hand Pump	3.4	5.93	5.62	2.58
23		*Gadarpur*	Jhagarpuri	Hand Pump	2.2	5.34	1.28	2.26
24			Mahabir Nagar	Hand Pump	2.6	2.71	1.23	2.68
25			Beria Daulat	Hand Pump	3.26	0.15	2.36	2.73
26			Bhagwanpur	Hand Pump	4.42	8.47	8.32	3.33
27			Pattharpui	Hand Pump	3.2	4.23	1.73	3.3
28			Badakhera	Hand Pump	NA	4.47	1.07	1.37
29			Lalpuri	Hand Pump	2.35	3.05	1.3	2.01

30		*Bazpur*	Bazpur	Dug Well	1.9	3.18	0.66	1.35
31			Jharkhandi	Hand Pump	1.54	2.17	0.79	1.16
32			Jogipura	Hand Pump	3.44	5.51	4.37	3.07
33			Banna Khera	Dug Well	3.90	5.23	5.65	3.77
34			Pritpur	Hand Pump	4.07	7.46	2.93	4.03
35			Badaripur	Hand Pump	4.41	8.03	3.3	3.26
36		*Kashipur*	Barkhare Pande	Hand Pump	7.21	10.81	5.02	6.09
37			Sultanpur Patti	Hand Pump	2.12	5.89	1.94	1.01
38			Kashipur	Dug Well	4.93	7.93	4.78	4.88
39			Bharatpur	Hand Pump	8.7	12.65	10.23	8.56
40			Dhanauri Patti	Hand Pump	3.34	5.2	5.26	2.99
41			Durgapur	Hand Pump	3.32	5.54	3.97	3.02
42			Shand Khera	Hand Pump	7.12	10.93	5.73	4.51
43		*Jaspur*	Jaspur	Hand Pump	16.4	15.51	10.18	9.21
44			Patrampur	Hand Pump	6.16	8.63	6.28	8.25
45			Angadpur	Hand Pump	13.27	5.45	14.45	13.94
46			Missarwala	Hand pump	6.37	15.98	7.92	10.46
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	Champawat	Champawat	Tanakpur	Dug Well	10.8	Water Not Available	13.3	9.61
2			Banbasa	Hand Pump	H.P Removed	11.66	0.43	4.73
3			Bastia	Hand Pump	37.42	31.08	18.24	23.15
4			Bichai	Hand pump	8.5	NA	6.03	6.86

Sl No.	District	Block	*Location Details*	Type of Well	Jan-18	May-17	Aug-17	Nov-17
1	*Pauri Garhwal*	*Dugadda*	Kaudia (Kotdwar)	Hand Pump	53.96	54.16	54.16	53.09
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**Jan-18**	**May-17**	**Aug-17**	**Nov-17**
1	*Uttarkashi*	*Chinyalisaur*	Chinyalisaur	Hand Pump	23.79	28.45	26.13	21.27
2		*Dunda*	Devidhar	Hand Pump	9.05	10.75	4.34	8.49
3			Uttarkashi	Hand Pump	17.09	17.26	14.71	17.12
4		*Naugaon*	Barkot	Hand Pump	16.75	16.02	16.68	16.52
5			Sharukhet	Hand Pump	43.46	25.7	24.28	37.99
6			Ganeshpur	Hand Pump	17.12	17.13	13.44	17.04
7		*Bhatwari*	Maneri	Hand Pump	29.81	28.9	29.33	34.57

NA: Not Available

DEPTH TO WATER LEVEL

5.1.1 May 2017

The depth to water level data was analyzed for 151 Ground Water Monitoring Wells in Uttarakhand during May 2017 and is given in ***Table 6.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 92.55 m bgl at Ladpur in Dehradun district whereas the shallowest water level was 0.15 m bgl at Beria Daulat in Udham Singh Nagar, district. The depth to water level in the range of 0–5 m bgl was recorded in 30 ground water monitoring wells, which is 19.87% of the total number of wells. Water level in the range of 5–10 m bgl was shown by 45 monitoring wells (29.80% of total number), whereas deeper water level of 10–15 m bgl was recorded in 28 monitoring wells, which was 18.54% of the total number. The deepest water level of >15 m bgl was shown by 48 monitoring wells, which is 31.79% of the total monitoring wells in Uttarakhand during May 2017.

Table 6: District wise categorization of depth to water level data, May 2017

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	49	1.56	92.55	2	4.08	9	18.37	14	28.57	24	48.98

Haridwar	39	1.78	67.57	11	28.21	12	30.77	8	20.51	8	20.51
U. S. Nagar	44	0.15	15.98	17	38.64	22	50.00	3	6.82	2	4.55
Nainital	8	5.1	79.98	0	0.00	1	12.50	1	12.50	6	75.00
Champawat	2	11.66	31.08	0	0.00	0	0.00	1	50.00	1	50.00
Uttarkashi	8	5.69	28.9	0	0.00	1	12.50	1	12.50	6	75.00
Pauri Garhwal	1	--	54.16	0	0.00	0	0.00	0	0.00	1	100.00
Total	**151**	**0.15**	**92.55**	**30**	19.87	**45**	29.80	**28**	18.54	**48**	31.79

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***May 2016*** is shown in ***Fig. 4*** *(Dehradun, Section),* ***Fig.5*** *(Haridwar section)* and ***Fig. 6*** *(Nainital-Udham Singh Nagar-Champawat Section)*.

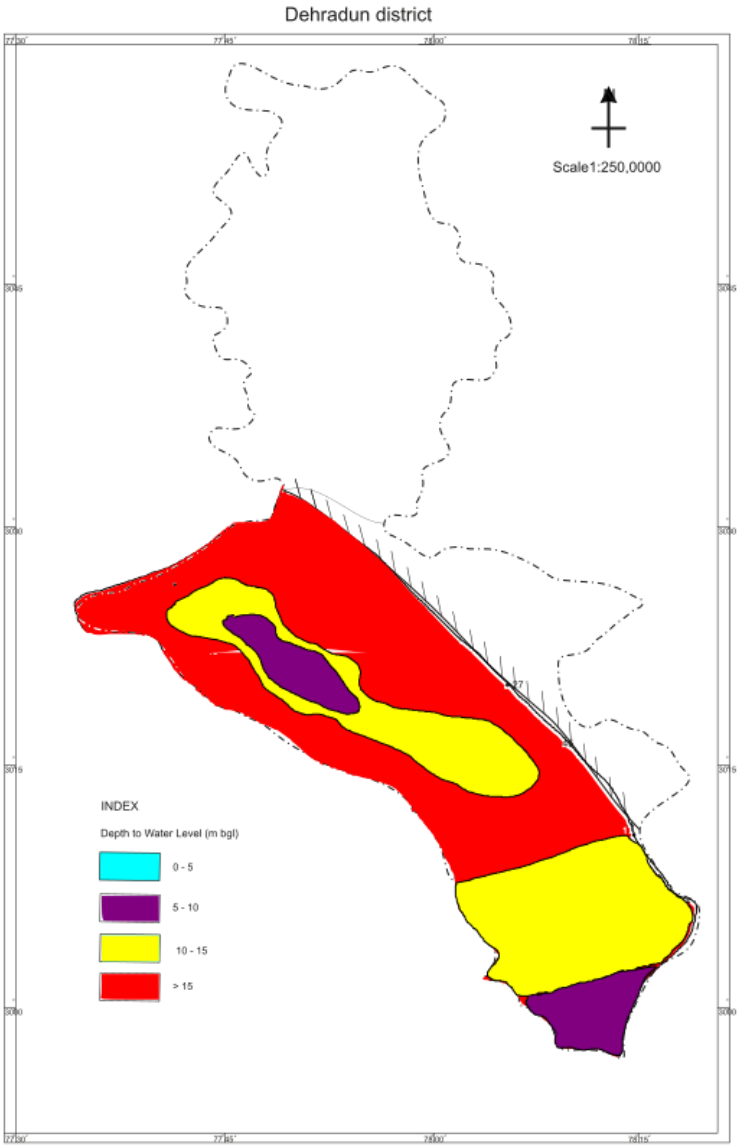


Figure 4 Depth To water Level Map (May 2016), Dehradun District

A study of Fig. 4 indicates that the major part of the Dehradun district shows deeper water levels (more than 15m). The water level in the range of 10-15 m is observed in the form of a narrow band covering north central and central part of Doon valley and

also as small patch around the Khadri Khadakmaf & Motichur. The water level in the range of 5-10 m occurs southern section.

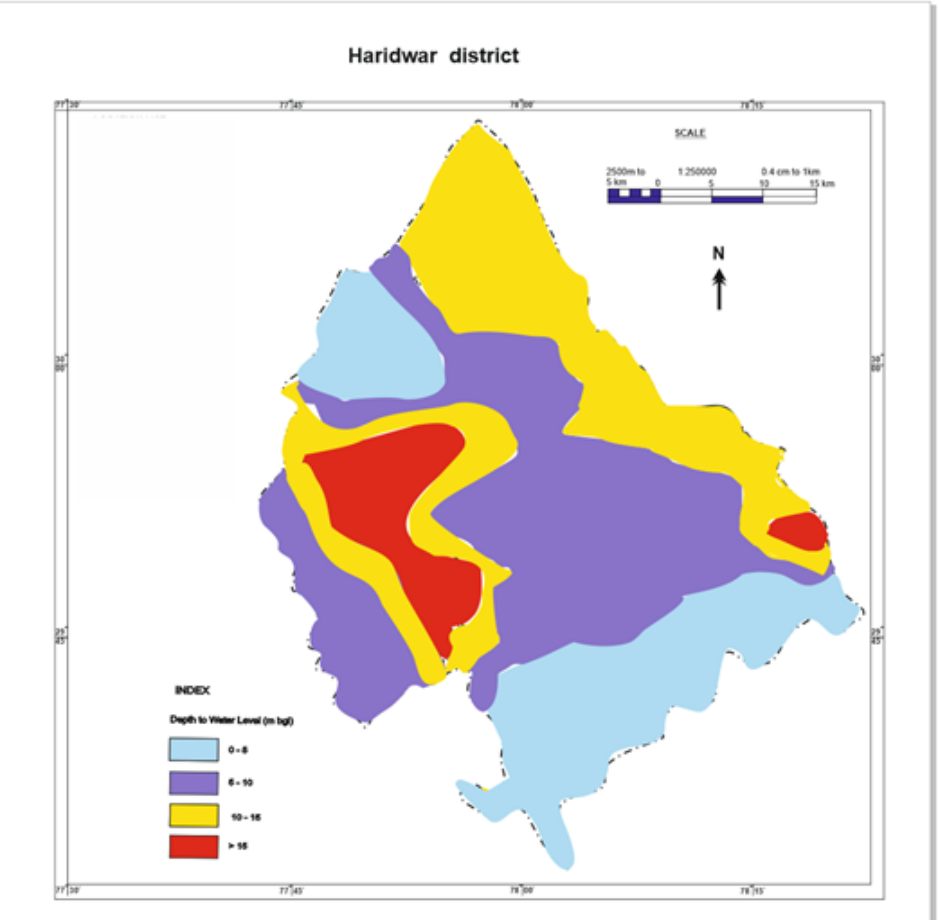


Figure 5 Depth To water Level Map (May 2017), Haridwar District

The visual interpretation of the **Fig. 5** indicates that the shallowest water level in the range of 0-5m occurs mostly in the southern part of the Haridwar district and also as Lenticular patch around Bahabalpur. The shallowest water levels in the range of 5-10m occurs in central and north wastern part of the Haridwar district. The water level in the range of 10-15m zone occurs in the northern part of Haridwar district. The deepest water level in the range of more than 15m occurs as an isolated patch in western part of the district and Laldhang (which demarcates the Bhabar zone).

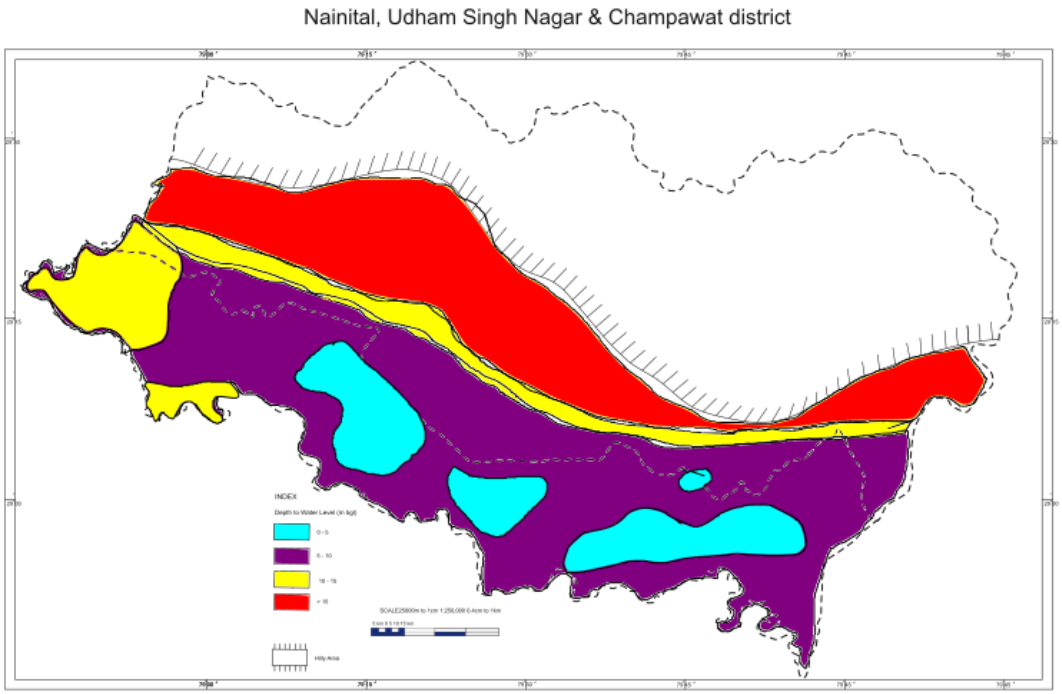


Figure 6 Depth To water Level Map (May 2016), US Nagar – Nainital - Champawat District

The visual interpretation of the **Fig. 6** indicates that the shallowest water level i.e. 0-5m observed as long isolated patches in Udham Singh Nagar district. The water level in the range of 5-10m is observed as majority in Udham Singh Nagar district. The water level in the range of 10-15m occurs covering the 5-10 m water levels extending from north western part of the section to eastern part of the section; and also as isolated patch around in western part of Udham Singh Nagar. The deepest water level (>15 m)is running parallel to the 10-15 m water level zone from north western part of the section. In general, it is observed that the water level deepens from south to north in the section.

5.1.2 August 2017

During the month of August 2017, total of 159 Groundwater monitoring wells (including dug wells, hand pumps and piezometers) were monitoried in Uttarakhand State in District Dehradun, Haridwar, Udham Singh Nagar, Pauri Garhwal, Nainital and Champawat. The depth to water level data has been classified and is given in **Table 7.** A perusal of the table indicates that deepest water level was 83.94 m bgl at Ladpur Piezometer in District Dehradun district while the shallowest water level was 0.43 m bgl at Banbasa in Champawat district. The analysis of depth to water level data has also shown that shallowest water level of 0-5 m was recorded by 57 monitoring wells, which was 35.85% of the total number. Depth to water level in the range of 5-10 m was shown by 42 wells (26.42% of total number), whereas the deeper water levels of 10-15 m was shown by 20 wells (12.58% of total) whereas the deepest water levels (>15 m) was recorded by 39 monitoring wells, which was 24.53% of the total number of wells in Uttarakhand monitored during August 2017.

Table 7: District wise categorization of depth to water level data, August 2017

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	49	0.46	83.94	4	8.16	23	46.94	4	8.16	18	36.73
Haridwar	39	0.93	66.46	14	35.90	9	23.08	7	17.95	8	20.51
U. S. Nagar	46	0.44	14.45	34	73.91	8	17.39	4	8.70	0	0.00
Nainital	12	3.08	54.26	3	25.00	0	0.00	2	16.67	7	58.33
Champawat	4	0.43	18.24	1	25.00	1	25.00	1	25.00	1	25.00
Uttarkashi	8	4.34	29.33	1	12.50	1	12.50	2	25.00	4	50.00
Pauri Garhwal	1	--	52.11	0	0.00	0	0.00	0	0.00	1	100.00
Total	**159**	**0.43**	**83.94**	**57**	35.85	**42**	26.42	**20**	12.58	**39**	24.53

The depth to water level maps (August 2017) for Dehradun section in fig 7, Haridwar section is given in Fig. 8 and for Udham Singh Nagar-Nainital-Champawat section is given in Fig. 9.

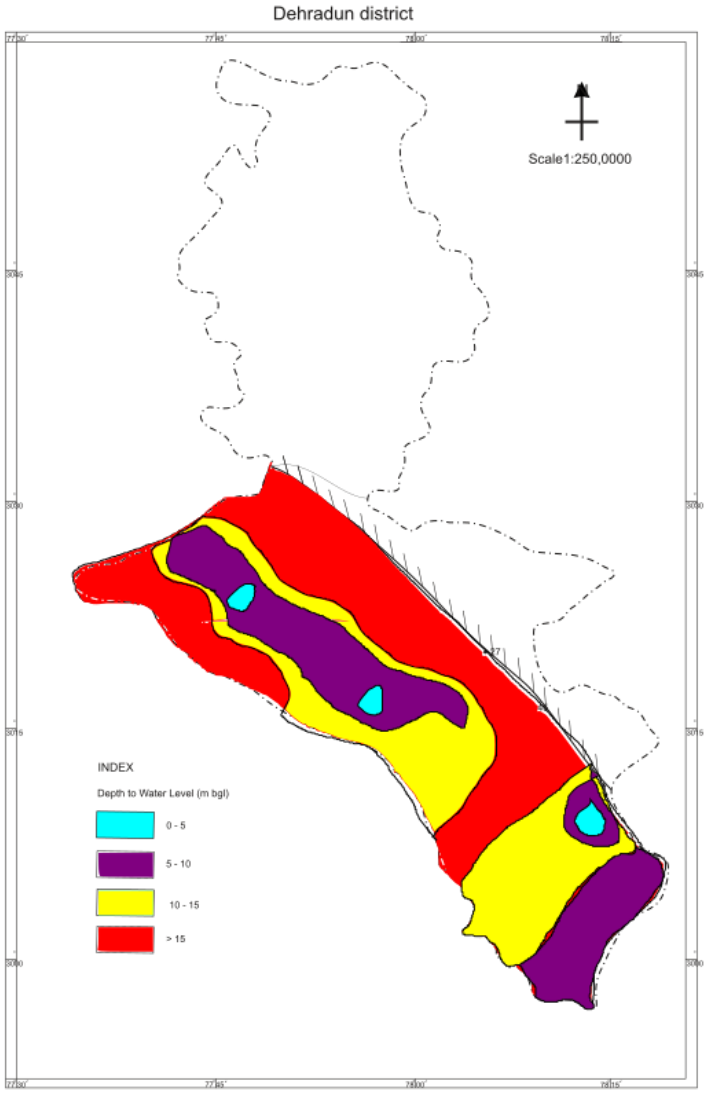


Figure 4 Depth To water Level Map (August 2016), Dehradun District

A perusal of **Fig.7** indicates that the shallowest water level (0-5 m) is observed as lenticular isolated patches. The water levels in the range of 5-10m are observed as the outlier of the shallowest water level and southern part of the district. The water level in the range of 10-15m is observed in central part of valley. More than 45% of the Doon valley shows the medium deep water levels (5-10m).

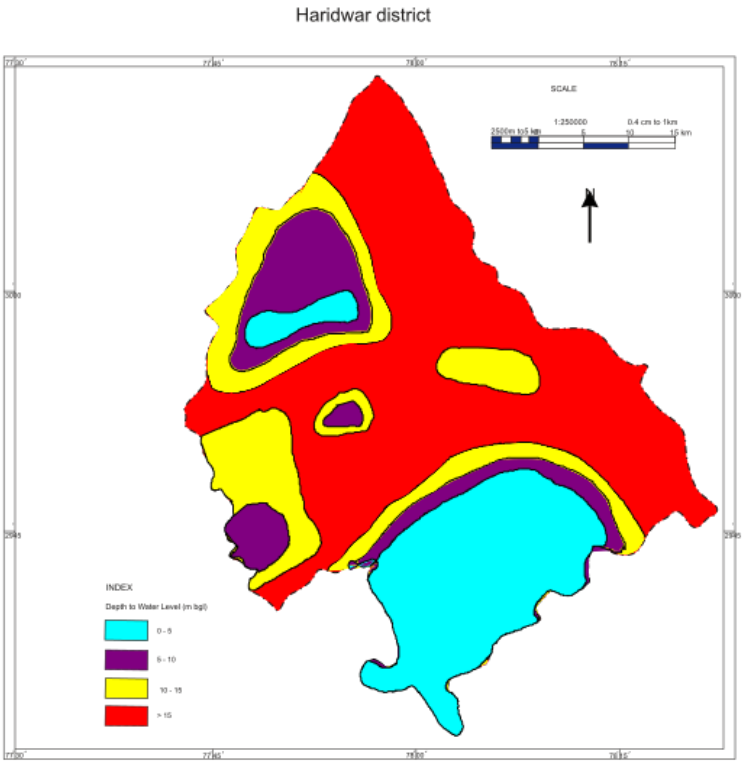


Figure 5 Depth To water Level Map (August 2017), Haridwar District

A perusal of Fig. 8 indicates that the minimum depth to water level i.e 0-5 m is observed in southern part of the Haridwar district and also as lenticular patches around Sarai - Bahabalpur. The shallowest water levels in the range of 5-10m occurs as linear zone trending from south-west to south-east and also occurs in north wastern part of the Haridwar district. The deeper water levels in the range of 10-15 m are observed mainly in the western part of the district. Whereas, the deepest water levels (>15) occurs in eastern part and around Sikhar and Laldhang (which demarcates the Bhabar zone).

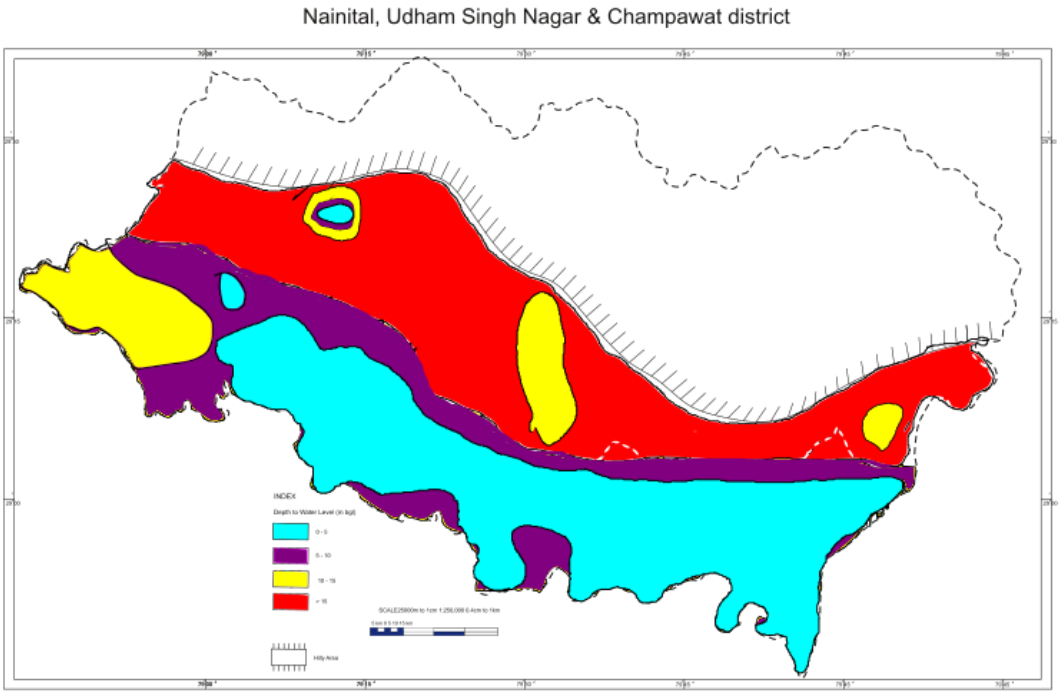


Figure 6 Depth To water Level Map (August 2017), US Nagar – Nainital - Champawat District

Interpretation of **Fig. 9** has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar- Nainital- champawat section. The shallowest water level (0-5 m) is observed mainly in the central, southern and south-eastern part of the section and as isolated patches. The water level in the range of 5-10m is observed as outlier to 0-5 m zone. This zone is also observed as narrow band running from North Western part of the Nanital district covering central part of district and extending till eastern part of the Champawat district. The water level in the range of 10-15m occurs covering the 5-10 m water levels extending from north western part of the section to eastern part of the section; and also as isolated patch. The deepest water level (>15 m)is running parallel to the 10-15 m water level zone from north western part of the section.

5.1.3. November 2017

The depth to water level data is available for 160 Ground Water Monitoring Wells of Uttarakhand during November 2017. The data has been analyzed and shown in ***Table 8***. During this period, the deepest water level of 84.09 m bgl was observed at Ladpur Piezometer (Dehradun district) while the shallowest water level of 0.67 m bgl was observed at Dhyanpur in Udham Singh Nagar district. The analysis of depth to water level data shows that out of 160 wells, 62 wells (38.75% of total number) have recorded shallowest water level in the depth range of 0–5 m whereas water level in the range of 5-10 m was recorded in 38 monitoring wells (23.75% of the total number). Deeper water level of 10–15 m was observed in 15 wells, which was 12.86% of the total number whereas the deepest water level of >15 m bgl was recorded in 46 wells (28.75% of total wells) in Uttarakhand during November 2017.

Table 8: District wise categorization of depth to water level data, November 2017

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	49	1.26	84.09	5	10.20	18	36.73	7	14.29	19	38.78
Haridwar	39	1.47	57.42	15	38.46	11	28.21	4	10.26	9	23.08
U. S. Nagar	46	0.67	13.94	39	84.78	5	10.87	2	4.35	0	0.00
Nainital	13	2.78	72.58	2	15.38	2	15.38	0	0.00	9	69.23
Champawat	4	4.73	23.15	1	25.00	1	25.00	2	50.00	1	25.00
Uttarkashi	8	8.49	37.99	0	0.00	1	12.50	0	0.00	7	87.50
Pauri Garhwal	1	--	53.09	0	0.00	0	0.00	0	0.00	1	100.00
Total	**160**	**0.67**	**84.09**	**62**	38.75	**38**	23.75	**15**	9.38	**46**	28.75

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for November 2017 is shown in **Fig. 10** (Dehradun Section), and **Fig. 11** Haridwar Section) and **Fig. 12** (Nainital, Udham Singh Nagar and Champawat Section

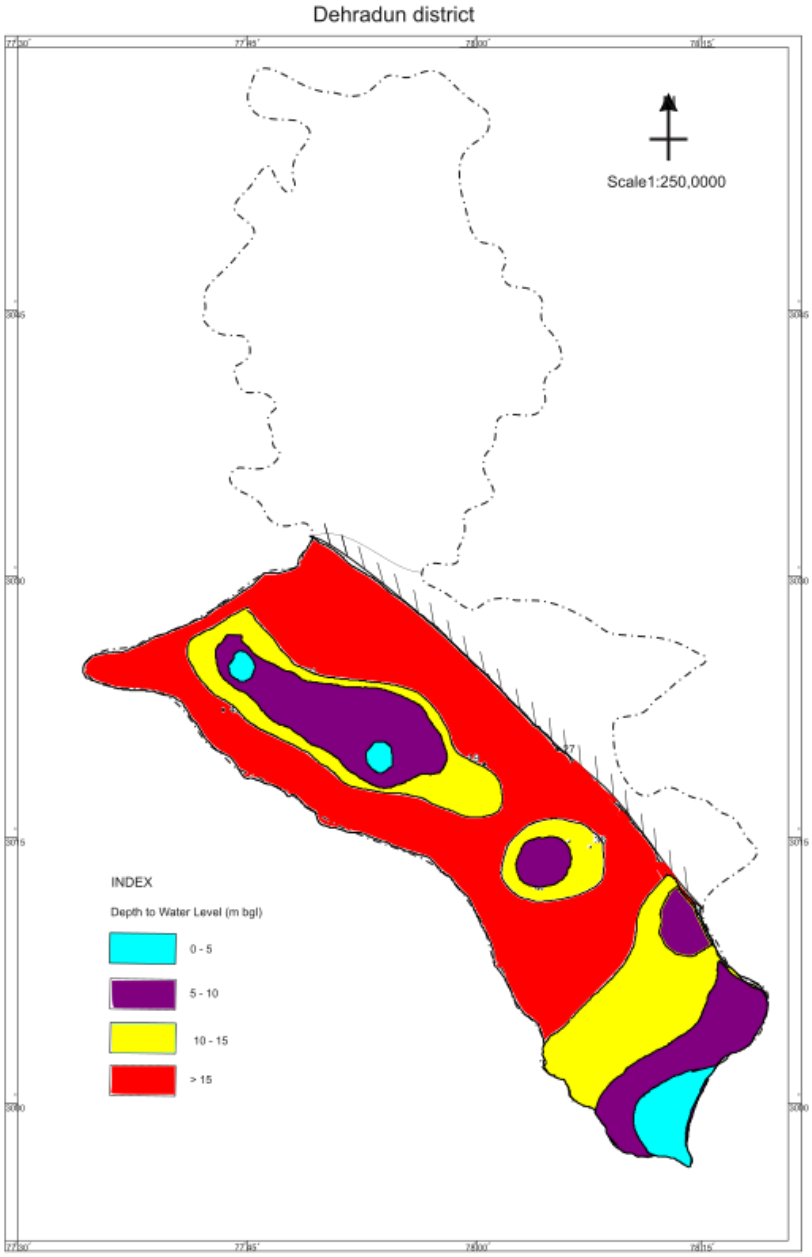


Figure 10 Depth To water Level Map (November 2017), Dehradun District

A perusal of **Fig. 10** reveals that the shallowest water levels (0-5m) are observed as isolated patches and as narrow linear in southern part. The water levels in the range of 5-10m are observed as more or less lenticular zone in north central and central part of Doon valley as outlier to the 0-5m water level zones. The water levels in the range of 10-15m are observed as a narrow concentric zone surrounding the 5-10m water level zone in north central and central part of Doon valley. Majority of the Doon Valley shows the water deeper than 15 m.

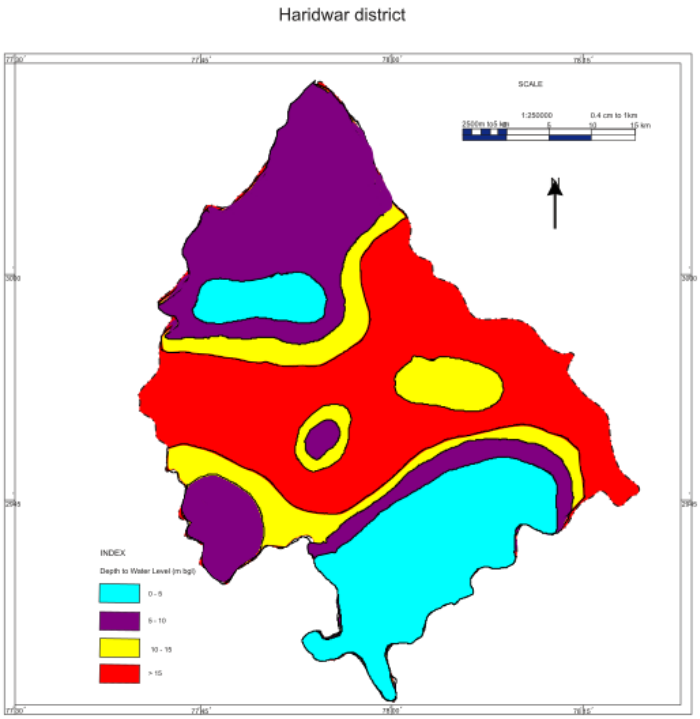


Figure 7 Depth To water Level Map (November 2017), Haridwar District

A perusal of **Fig. 11** reveals that the shallowest water level (0-5 m) occurs mostly in the Southern part of Haridwar District and as isolated patch around Bahabalpur - Rathura. The water levels in the range of 5-10m are observed in the Northern part of the district and also as broad continuous band extending from south western part covering central part of the district and then tapers to the south eastern part of the Haridwar District. The water levels in the range of 10-15 m are observed in between 5-10m water level zone and as elliptical patch around the Nizampur - Landhaura. The deeper water level (>15m)are observed as inlier in the 10-15m water level zone in southeastern part of the district; as isolated patche around Laldhang.

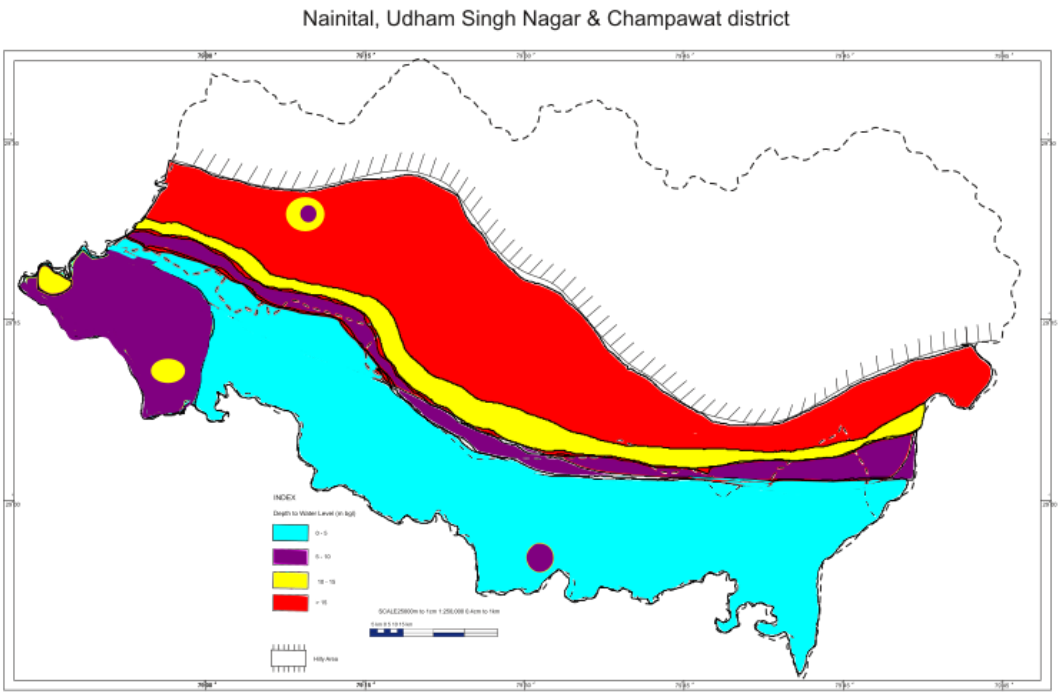


Figure 8 Depth To water Level Map (November 2016), US Nagar – Nainital - Champawat District

Interpretation of **Fig. 12** has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar- Nainital- champawat section. The shallowest water level (0-5 m) is observed mainly in the central, southern and south-eastern part of the section (maldhan Colony – Jogipura – Beria Daulat – Pathar Chatta – Gangapur – Nanak Mata). The water level in the range of 5-10m is observed around Bharatpur – Patrampur – Missarwala and Majhola as isolated patch in Udham Singh Nagar District. This zone is also observed as narrow band running from North Western part of the Nanital district covering central part of district and extending till eastern part of the Champawat district. The water level in the range of 10-15m occurs covering the 5-10 m water levels extending from north western part of the section to eastern part of the section; and also as isolated patch around the Jaspur. The deepest water level (>15 m)is running parallel to the 10-15 m water level zone from north western part of the section. The deepest water levels (>15 m) are observed mostly in northern part of Bhabhar Belt.

5.1.4 January 2018

The depth to water level data was analysed for 156 Ground Water Monitoring Wells in Uttarakhand during January 2018 and is given in ***Table 9.*** Analysis of depth to water level data given in the table indicates that the deepest water level was 91.05 m bgl in a piezometer at Ladpur, Dehradun district whereas the shallowest water level was 0.83 m bgl at Hussainpur in Haridwar. The shallowest depth to water level of 0–5 m bgl was recorded by 51 monitoring wells, which was 32.69 % of the total number of wells. Water level in the range of 5-10 m bgl was also shown by 33 wells (21.15% of total number of wells), whereas deeper water level of 10–15 m bgl was recorded by 27 monitoring wells, which was 18.59% of the total number of wells. The deepest water level of >15 m bgl was shown by 45 monitoring wells, which was 28.85% of the total number of wells in Uttarakhand monitored in January 2018.

Table 9: District wise categorization of depth to water level data, January 2018

District	No. of stations analyzed	Depth to water level (m bgl)		Depth to water level (m bgl)							
				0-5		5 to 10		10 to 15		>15	
		Min	Max	No.	%	No.	%	No.	%	No.	%
Dehradun	49	2.52	91.05	3	6.12	11	22.45	16	32.65	19	38.78
Haridwar	39	0.83	57.19	13	33.33	10	25.64	9	23.08	7	17.95
U. S. Nagar	43	1.54	16.4	33	76.74	8	18.60	1	2.33	1	2.33
Nainital	13	3.64	68.18	2	15.38	2	15.38	0	0.00	9	69.23
Champawat	3	8.5	37.42	0	0.00	1	33.33	1	33.33	1	33.33
Uttarkashi	8	9.05	43.46	0	0.00	1	12.50	0	0.00	7	87.50
Pauri Garhwal	1	--	52.11	0	0.00	0	0.00	0	0.00	1	100.00
Total	**156**	**0.83**	**91.05**	**51**	32.69	**33**	21.15	**27**	17.31	**45**	28.85

The depth to water level map of the plain areas and parts of hilly areas of Uttarakhand for ***January 2017*** is shown in ***Fig. 13*** *(Dehradun Section),* ***Fig. 14*** *(Haridwar Section)* and ***Fig. 15*** *(Nainital, Udham Singh Nagar and Champawat Section).*

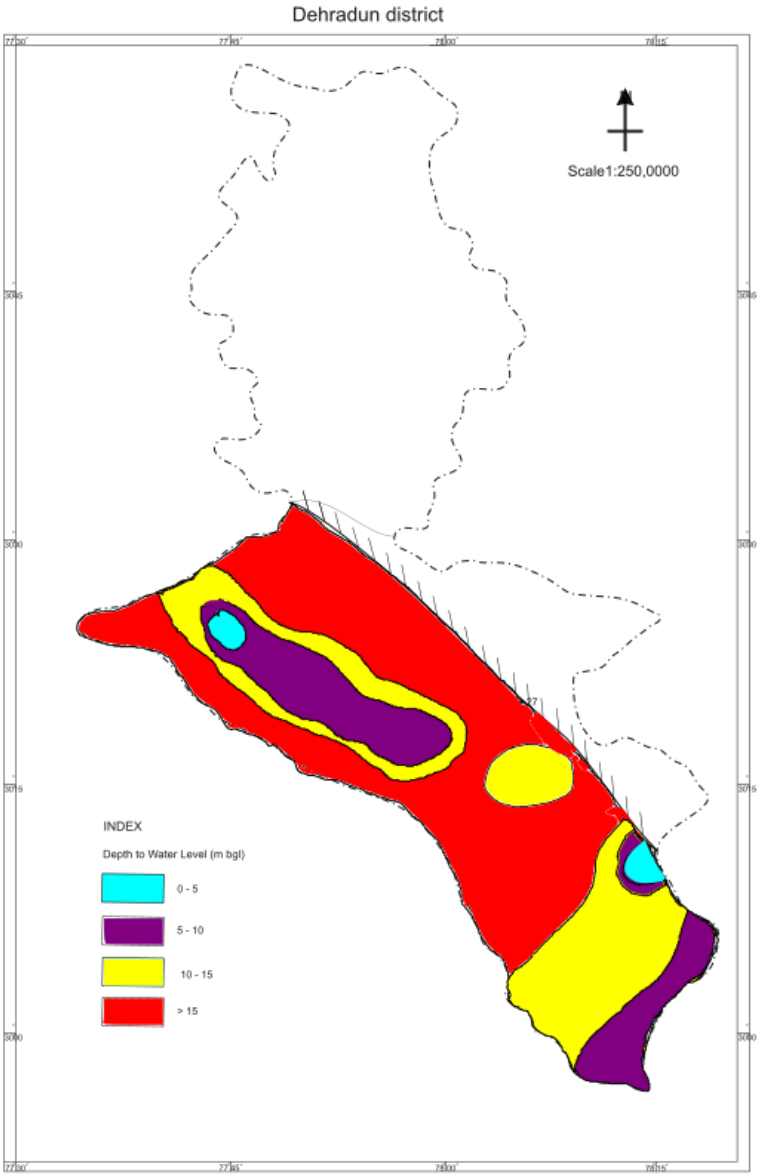


Figure 9 Depth To water Level Map (January 2017), Dehradun District

A perusal of **Fig. 13** reveals that the shallowest water levels (0-5 m) are observed in the isolated patches around Dandhi. Water levels in the range of 5-10 m are observed in narrow zones in Rampur – Redarpur – Dharmawala - Selaqui section and as isolated patch around Khandgaon. The water level in the range of 10-15 m is observed as outlier to the 5-10 m water level zone in central part of Doon valley. This zonwe is also dominant in Southern part of Doon Gravels around Lal tappar- Motichur - Rhishikesh Section. More than 70 % of the Doon valley shows deeper water levels (>15m).

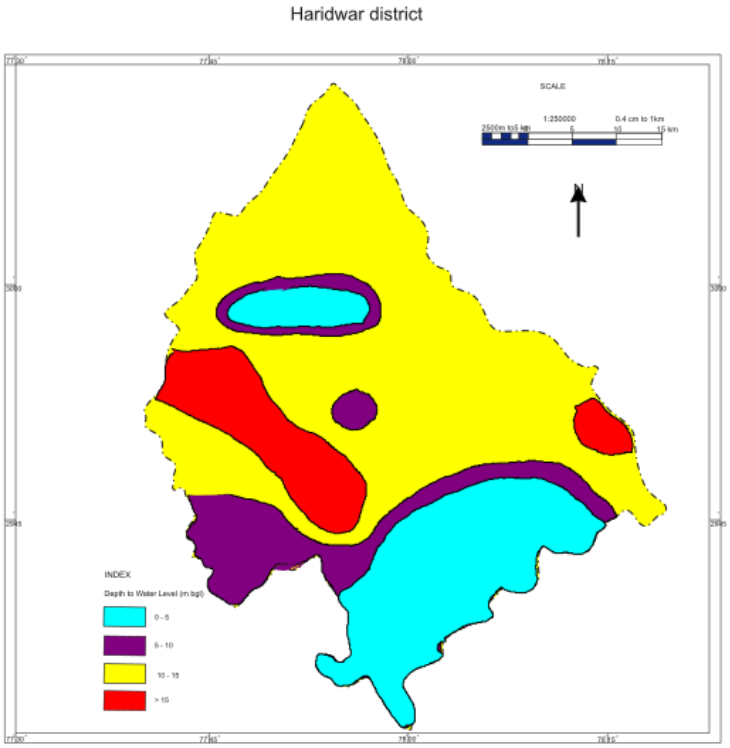


Figure 10 Depth To water Level Map (January 2017), Haridwar District

A study of ***Fig. 14*** that the shallowest water levels in the range of 0-5m occurs dominantly covering the southern Part of Haridwar District (Bhikkampur –Shapur Shitlakhera – Dallawala section) and as isolated patch around Bahabalpur. The water levels in the range of 5-10m observed around the Buggawala – Bandarjud section in the north and also as broad continuous band extending from south western part covering central part of the district and then tapers to the south eastern part of the Haridwar District. The water levels in the range of 10-15 m are observed around Iqbalpur – Bhagwanpur – Bahadrabad – Sarai in the central part of the distric and as outlier of > 15m water level zone around Manglaur. Deeper water level (>15m) occurs as isolated patches around Chudiala, Sikhar and Laldhang.

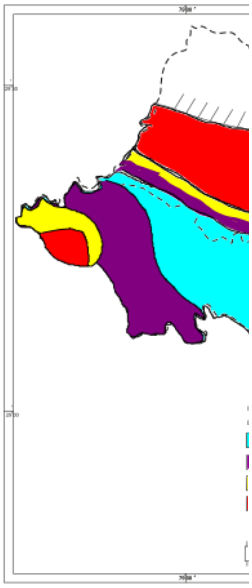


Figure 15 Depth To water Level Map (January 2017), US Nagar – Nainital - Champawat District

Interpretation of Fig. 15 has again revealed that depth to water level generally increases from south to north in Udham Singh Nagar- Nainital- champawat section. The shallowest water level (0-5 m) is observed mainly in the central, southern and south-eastern part of the section (Maldhan Colony – Jogipura – Beria Daulat – Pathar Chatta – Gangapur – Nanak Mata). The water level in the range of 5-10m is observed around Kashipur – Patrampur - Angadpur – Missarwala; and as isolated patch around Chakarpur & Kichha in Udham Singh Nagar District. This zone is also observed as narrow band running from North Western part of the Nanital district covering central part of district and extending till eastern part of the Champawat district. The water level in the range of 10-15m occurs covering the 5-10 m water levels extending from north western part of the section to eastern part of the section; and also as isolated patch around the Jaspur – Bharatpur in Udham Singh Nagar district. The deepest water levels (>15 m) are observed mostly in northern part of Bhabhar Belt. The deepest water level (>15 m) is running parallel to the 10-15 m water level zone from north western part of the section continuing upto the Bastia in the Nanital district.

5.2 DISCHARGE OF SPRINGS

The discharge data of thirty-six cold-water springs in Dehradun, Nainital, Uttarkashi and Almora districts for the months of May, August, November 2017 and January 2018 is given in ***Table 10.*** A study of the table shows that spring discharge is lowest in pre-monsoon (May) whereas during post-monsoon (August), the discharge increased significantly. This indicates that rainfall is the principal contributing factor for variation in spring discharge.

A perusal of ***Table 10*** indicates that discharge of the cold-water springs during the period May 2016-January 2017 varies from a minimum measurable discharge of 1.27 LPM at Someshwar in January 2017 to a maximum of 235 LPM at Sipahidhara (August 2016). Discharge of springs varies within wide limits during the intervening period.

In Dehradun district, spring discharge varies between 5 LPM at Soda Sarauli in January, 2018 and 96 LPM at Soda Sarauli in August 2017. In Nainital district, spring discharge varies from a minimum of 2 LPM at Kudaghat (May 2017) to a maximum of 333.33 LPM at Sipahidhara (August 2017). In Almora district, the spring discharge was found to be varying from a minimum of 0.11 LPM at Ramghat in May 2017 to a maximum of 115.38 LPM at Dhansari in August, 2017. In Uttarkashi district, spring discharge was varying from 1.95 LPM at Dharasau in November, 2017 to a maximum of 87 LPM in Ganganani in January 2018.

Table 10: Discharge of Springs in May, August, November 2017 and January 2018

Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	Dehradun	*Raipur*	Soda Saroli	Spring	10 lpm	96 lpm	23.54 lpm	5 lpm
2			Bhatta	Spring	6 lpm	88 lpm	40 lpm	12 lpm
3		*Sahaspur*	Khandoli	Spring	30 lpm	42 lpm	58 lpm	10 lpm
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	Nainital	*Bhimtal*	Amritpur (Ranibagh)	Spring	7.24 lpm	111.11 lpm	30.30 lpm	8.72
2			Salari	Spring	6.24 lpm	30.90 lpm	3.88 lpm	15.15 lpm
3			Dogaon	Spring	30 lpm	40.82 lpm	18.18	6.64 lpm
4			Sipahi Dhara	Spring	175.39 lpm	333.33 lpm	157.89 lpm	100 lpm
5			Garampani	Spring	16.22 lpm	16.13 lpm	16.76 lpm	25.42 lpm
6			Jyolikot	Spring	7.50 lpm	66.67 lpm	19.61	12.5 lpm

7			Kudaghat (Kuda Pahar)	Spring	2.00 lpm	15.79 lpm	21.13	NA
Sl No.	***District***	***Block***	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	Almora	*Tarikhet*	Patali Talla	Spring	9.19 lpm	5.73 lpm	19.11 lpm	6.04 lpm
2			Patali Malla	Spring	18.63 lpm	8.09 lpm	6.16 lpm	7.41 lpm
3			Baniya Diggi	Spring	1.62 lpm	12.10 lpm	6.13 lpm	7.44 lpm
4		*Hawalbagh*	Katarmal	Spring	8.52 lpm	18.52 lpm	28.30 lpm	21.9 lpm
5			Dharanaula	Spring	9.06 lpm	8.96 lpm	8.93 lpm	5.45 lpm
6			Palna	Spring	1.92 lpm	3.18 lpm	3.58 lpm	2.11 lpm
7			Bhagtola	Spring	1.03 lpm	12.99 lpm	NA	NA
8			Jholi	Spring	18.29 lpm	10.91 lpm	15.87 lpm	10.75 lpm
9			Itola	Spring	2.08 lpm	5.69 lpm	4.07 lpm	NA
10		*Takula*	Chanoda	Spring	0.94 lpm	3.62 lpm	1.19 lpm	0.87 lpm
11			Guruda-I	Spring	13.82 lpm	15.96 lpm	15.46 lpm	14.02 lpm
12			Chhani Bartola	Spring	5.36 lpm	21.58 lpm	7.26 lpm	7.41 lpm
13		*Chaukhutiya*	Dhansari	Spring	58.82 lpm	115.38 lpm	58.82 lpm	36.59 lpm
14			Deepakot	Spring	7.79 lpm	12.35 lpm	11.24 lpm	11.49 lpm
15			Dhalnagaon	Spring	5.08 lpm	28.85 lpm	12.88 lpm	24.39 lpm
16			Simalkhet	Spring	8.26 lpm	32.61 lpm	10.45 lpm	9.68 lpm
17			Peepal Dhar	Spring	8.26 lpm	83.33 lpm	68.18 lpm	41.1 lpm
18		*Bhikiasain*	Ramghat	Spring	0.11 lpm	2.92 lpm	23.81 lpm	9.62 lpm
19			Naula	Spring	11.76 lpm	7.01 lpm	6.41 lpm	6.61 lpm
20		Someshwar	Mehragaon (Someshwar)	Spring	0.97 lpm	2.37 lpm	1.08 lpm	0.56 lpm

21			Lodh	Spring	2.28 lpm	4.49 lpm	8.31 lpm	18.07 lpm
22			Bhoolgaon SP	Spring	24.00 lpm	93.75 lpm	46.15 lpm	31.58 lpm
Sl No.	**District**	**Block**	***Location Details***	**Type of Well**	**May-17**	**Aug-17**	**Nov-17**	**Jan-18**
1	*Uttarkashi*	*Dunda*	Dharasu	Spring	3.32 lpm	3.07 lpm	1.95 lpm	2.59 lpm
2		*Bhatwari*	Nagal	Spring	16.65 lpm	14.18 lpm	6.51 lpm	3.16 lpm
3			Ratodi Sar	Spring	8.10 lpm	8.12 lpm	5.43 lpm	7.95 lpm
4			Ganganani Spring *	Spring *	26.22 lpm	10.83 lpm	6.67 lpm	87 lpm

NA: Not Available

5.3 LONG TERM (DECADAL) DEPTH TO WATER LEVEL

The available long-term data of ground water levels in some of the Ground Water Monitoring Wells of the state was analyzed to have an idea of the decadal (long-term) water level data and decadal versus current depth to water level fluctuations. The average value of depth to water level for selected Ground Water Monitoring Wells (based on availability of long-term water level data) was calculated for the past ten years (May, August and November for the period from 2007 to 2016 and January for the period from 2008 to 2017). The average depth to water level data available for Ground Water Monitoring Wells is given in ***Table 11.***

Table 11: Long-term (Decadal) Depth to Water Level Data, Uttarakhand State

State Uttarakhand					
District:Dehradun					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Khandgaon	NA	NA	NA	8.42857
2	Khadiri (Khadak Maf)	15.892	13.5983	13.7433	12.118
3	Rishikesh	6.29	3.17714	6.04571	5.00286
4	Lal Tappar	18.93	13.8886	12.7357	13.3443
5	Dandi	6.70667	4.51833	4.94833	5.896
6	Bhaniawala	32.465	17.9675	21.1175	25.4956
7	Kotimachak	21.0117	11.5757	16.5183	19.8286
8	Chandmari	NA	NA	26.1025	28.5125
9	Duggiawala	NA	NA	3.11	1.9
10	Kuanwala	15.175	9.13333	5.12571	9.47857
11	Gularghagti	13.045	8.50143	10.7157	10.7214
12	Balliwala	55.355	54.7514	54.2038	52.5078
13	Maldeota	12.725	4.08143	7.84714	10.3457
14	Nanurkhera	70.6338	68.4475	60.9438	61.5438
15	Tarla Nagal	75.8838	66.4275	67.8263	68.5156
16	Tarla Nagal	NA	54.4867	NA	54.72
17	Purukulgaon	28.135	16.55	23.6757	25.97
18	Majra	23.6429	21.8229	21.7443	20.2038
19	CGWB Office	57.7	54.6743	50.7817	51.9514
20	Harbanswala	53.5188	49.0675	44.08	49.1889
21	Kanwali	14.722	8.924	13.103	14.5611
22	Singhniwala	9.608	6.534	8.976	9.186
23	Ramgarh	7.4925	4.21125	6.51667	6.23333
24	Jhajra	12.7938	6.03375	7.19429	9.08
25	Jhajra	13.4871	5.636	7.23143	11.8843
26	Nanda ki Chowki	14.4589	7.34	8.819	9.81
27	Nanda ki Chowki	15.305	9.12	8.61	10.22
28	Selakui	11.4883	6.85333	8.593	9.114
29	Selakui	15.995	10.7586	13.5014	13.4529
30	Sabhawala	9.296	5.365	7.825	8.789

31	Rampura	13.724	6.898	11.496	11.976
32	Shankarpur	23.35	16.679	18.413	19.9033
33	Redapur	9.00375	6.11	5.03143	6.15556
34	Redapur	6.825	3.44857	4.16875	4.72
35	Badripur	8.85	7.38571	8.46714	8.76714
36	Judli	12.676	11.023	12.189	13.3478
37	Herbertpur	9.993	5.382	8.419	9.68
38	Vikas Nagar	25.698	20.8257	24.1614	26.2529
39	Dharmawala	4.54	3.374	4.32857	4.62429
40	Dakpatthar	26.4125	21.66	27.265	25.772
41	Dhakrani	16.4575	10.88	18.97	17.988
42	Timli	NA	NA	NA	56.062
District: Haridwar					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Shahidwala Grant	11.7	10.765	11.111	11.188
2	Sahidwala Grant	11.6783	8.486	9.19833	9.05667
3	Budhwa Shahid	4.53286	2.66857	3.04125	3.20875
4	Bugawala	7.52	5.49111	5.8125	5.9375
5	Bahabalpur	3.187	2.43556	2.94778	3.11
6	Bhagwanpur	20.133	16.166	17.394	14.277
7	Chudiala	19.635	17.78	18.3183	18.85
8	Iqbalpur	16.323	12.742	15.218	14.36
9	Jaswawala	NA	NA	4.1875	4.335
10	Bandarjud	10.4757	8.1175	7.90875	8.55375
11	Rathora	5.16571	4.27625	4.19875	5.24375
12	Bahadrabad	8.755	13.2317	12.745	11.7017
13	Sarai	11.3443	9.16375	10.7038	12.0288
14	Dhanpura	8.82333	4.64833	9.665	6.072
15	Shahpur Shitlakhera	5.03	2.802	3.64286	3.92625
16	Laldhang	62.38	60.274	56.0833	57.636
17	Bhogpur	4.11	1.95	2.585	3.412
18	Imlikhera	17.2917	12.4183	10.97	13.7783
19	Roorkee	7.594	5.395	6.348	6.063
20	Sikhar	19.9	18.4875	16.52	16.5
21	Khera Jat	6.8125	17.144	5.8425	6.0075
22	Nizampur	10.6725	20.262	10.3625	10.395
23	Jhabreda	10.376	7.538	9.437	8.453
24	Landhaura	18.075	16.0417	16.096	17.93
25	Lakhnauta	5.88429	5.14	4.9075	6.635
26	Gurukul Narsen	6.055	3.42833	5.156	5.815
27	Libhrahedi	8.9325	5.61	5.8775	6.486
28	Mudlana	17.9225	NA	17.81	17.768
29	Hussainpur	3.953	1.425	2.589	2.437

30	Laksar	4.2225	2.19	2.6725	2.8525
31	Bhikkampur	4.28667	2.12667	3.018	4.17833
32	Govardhanpur	4.19333	2.17667	3.052	2.0175
33	Dallawala	2.026	NA	1.64833	1.92333
34	Khanpur	NA	NA	NA	2.17143
District: Nainital					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Khaat Baans	33.9344	23.134	28.021	27.081
2	Kaladungi	27.009	8.352	7.04333	7.306
3	Kathgodam	20.601	47.4311	36.5456	41.1875
4	Peeru Madara	24.883	26.9175	26.937	27.927
5	Dhela	64.244	14.847	17.726	19.669
6	Belparao	NA	52.528	53.415	53.6238
7	Peeru Madara	NA	21.801	18.8344	20.229
8	Maldhan Colony	NA	2.248	4.255	3.605
9	Dhela	NA	NA	65.625	56.8263
10	Ram Nagar	NA	NA	NA	6.70444
11	Garjiya	4.509	2.966	4.233	4.559
12	Dohniya	NA	NA	61.83	58.7014
13	Chilkiya	NA	NA	52.395	NA
District: Udham Singh Nagar					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Kanchanpur (Majhola) HP	4.814	3.117	3.76	4.44444
2	Khatima	3.317	1.291	1.663	2.53
3	Sarasariya	6.7875	4.5275	2.894	3.812
4	Chakarpur	5.86111	4.751	4.479	NA
5	Barianjaniya	NA	NA	3.51	4.15
6	Sitarganj	3.354	1.333	1.788	1.758
7	Nanak Mata	5.173	2.321	2.985	3.649
8	Kalyanpur	NA	1.52	2.09556	2.196
9	Tukri	4.595	4.67	3.192	2.536
10	Begur Mod	NA	NA	3.285	3.375
11	Dhyanpur	NA	NA	1.605	1.8925
12	Bara	2.4	1.01	1.757	1.973
13	Kichha	7.72286	6.05	6.356	7.0375
14	Kamaria Pakki	7.28	3.92889	3.675	5.11333
15	Gangapur	3.313	2.869	2.392	2.654
16	Shantipuri	2.261	1.031	1.559	1.661
17	Patthar Chatta	2.976	2.009	2.61111	2.655
18	Rudrapur	4.1475	2.0275	2.99	2.97
19	Kanakpur	NA	NA	2.6875	2.8525

20	Rajpura	NA	NA	3.2675	2.2475
21	Pipaliya	NA	NA	NA	2.97
22	Jhagarpuri	2.869	1.28	1.88375	2.33778
23	Mahabir Nagar	2.7	1.247	2.055	2.655
24	Beria Daulat	3.949	1.99	2.719	3.048
25	Bhagwanpur	6.509	4.306	3.38	3.776
26	Pattharpui	NA	NA	NA	3.66
27	Lalpuri	NA	NA	1.62	1.9675
28	Bazpur	2.688	0.668	1.49	1.804
29	Jharkhandi	2.1975	1.585	1.242	1.23
30	Jogipura	6.97	3.967	4.16	4.508
31	Banna Khera	5.073	3.438	3.534	3.668
32	Pritpur	NA	NA	3.2475	3.525
33	Badaripur	NA	NA	3.64	4.5525
34	Barkhare Pande	8.40444	5.322	3.75125	6.05889
35	Sultanpur Patti	NA	NA	0.95	1.50286
36	Kashipur	6.568	3.20556	4.551	4.319
37	Bharatpur	8.858	7.065	6.374	6.05667
38	Dhanauri Patti	4.666	2.375	2.601	2.902
39	Durgapur	5.7375	3.1325	3.108	3.358
40	Shand Khera	NA	NA	5.3475	5.2025
41	Jaspur	9.745	10.896	9.198	11.1344
42	Patrampur	10.501	8.151	6.942	7.24556
43	Angadpur	6.55778	5.24333	5.1	4.53556
44	Missarwala	NA	NA	7.455	5.8225
District: Champawat					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Tanakpur	NA	6.82778	9.158	10.429
1	Banbasa	6.984	4.07286	6.5	NA
3	Bastia	30.498	23.6789	24.3756	31.018
4	Bichai	NA	NA	12.2775	10.965
District: Pauri Garhwal					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Kaudia (Kotdwar)	54.1483	56.402	51.6917	53.772
District: Uttarkashi					
Sl No.	Location Details	AVG May 2007-16	AVG Aug 2007-16	AVG Nov 2007-16	AVG Jan 2008-17
1	Chinyalisaur	46.4625	NA	30.446	43.912
2	Devidhar	12.3725	NA	13.65	14.124
3	Uttarkashi	17.0125	NA	15.714	18.665
4	Barkot	16.4625	NA	15.958	16.43
5	Sharukhet	36.87	NA	32.214	33.975
6	Ganeshpur	15.5275	NA	16.362	17.5
7	Maneri	NA	NA	NA	19.21

A perusal of the long-term (decadal) depth to water level data given in ***Table11*** indicates that the depth to water level varies widely. The minimum long-term water level is 0.668 m at Bazpur in Udham Singh Nagar District in August whereas the maximum was 75.88 m bgl at Tarla Nagal in Dehradun district in May.

The table also shows that for Dehradun district, the minimum long-term water level is 1.9 m bgl at Duggiawala in January whereas the maximum is 75.88 m bgl at Tarla Nagal in May. In Haridwar district, decadal water level is varying from 1.42 m bgl at Husseinpur in August to the maximum of 62.38 m bgl at Laldhang in May. In Udham Singh Nagar district, the long-term depth to water level is varying from 0.66 m bgl at Bazpur in August to 11.13 m bgl at Jaspur hand pump in January viz. in the pre-monsoon period. The decadal water level in Nainital district was varying from 2.24 m bgl at Maldhan Colony in August to a maximum of 65.62 m bgl at Dhela hand pump in November. Long-term depth to water level in Champawat district was ranging from 4.07 at Banbasa in August to 31.01 m bgl at Bastia Handpump in January.

5.4 WATER LEVEL FLUCTUATION

The changes in ground water level in response to recharge and ground water withdrawal are important aspects for study of the overall hydrogeological scenario of an area. The water level fluctuation is calculated in each case under the following three categories.

- Changes in water level during each period of observation with respect to average water level for the last ten years for that period.
- Changes in water level during each season/period with respect to observed data of pre-monsoon water level during the same year.
- Changes in water level during each season/period with respect to water levels observed in previous year of the same period.

Tables and maps, which show the long-term (decadal), yearly and seasonal water level fluctuations, were prepared for the monitoring wells of Dehradun, Haridwar, Udham Singh Nagar, Nainital and Champawat district. The analysis of water level fluctuation data and conclusion drawn from it are discussed below.

5.4.1 DECADAL (LONG-TERM) WATER LEVEL FLUCTUATION

5.4.1.1 Water Level Fluctuation (May 2007-2016 versus May 2017)

The analysis of decadal depth to water level data for 114 ground water monitoring wells is given in ***Table 12***. A perusal of the table indicates that the minimum long-term rise in the range of 0-2 m is observed in 31 monitoring wells (27.19 % of the total number) whereas higher rise in the range of 2-4 m is observed in 9 wells (7.89 % of total). The 8 no of well (7.02%) recorded the decadal rise in water level (>4 m). The lowest long-term decline in the range of 0-2 m is recorded in 42 wells, which is 36.84 % of the total number. Higher long-term decline in the range of 2-4 m is recorded in 14 wells, which is 12.28 % and the highest decline of >4 m is recorded in 10 wells, which is 8.77 % of the total number. Analysis of the decadal data also shows that the lowest decadal rise is 0.09 m at Jharkhandi in Udham Singh Nagar district while the highest rise is 25.43 m at Khaat Baans in Nainital district. The lowest long-term decline in water level is 0.01 m at Mahabir Nagar in Udham Singh Nagar district while the highest is 18.12 m at Peeru Madara in Dehradun district.

The decadal water level fluctuation map for average (May 2007-2016) versus May 2017 is shown in ***Fig.16*** *(Dehradun Section),* ***Fig.17*** *(Haridwar section)* and ***Fig. 18*** *(Nainital-Udham Singh Nagar-Champawat section)*.

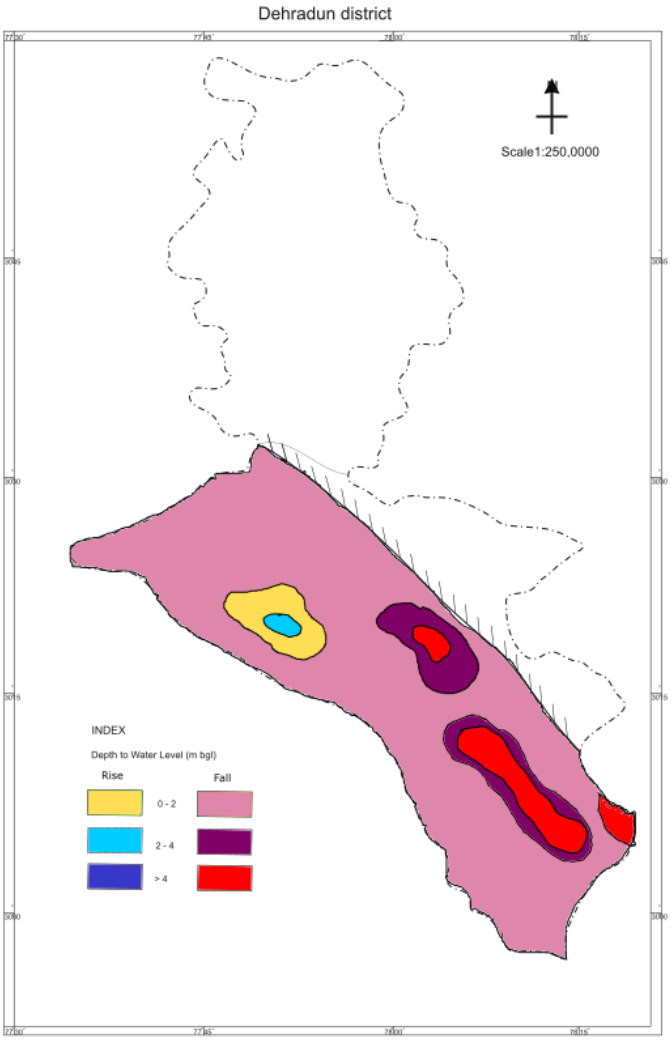


Figure 116 Decadal Water Level Fluctuation Map (May 2007-2016 vs 2017), Dehradun District

A study of **Fig. 16** reveals that the minimum rise of 0-2 m is observed in narrow patches around Nanda Ki Chowki and Herbertpur – Rampur area. Higher decadal rise of 2-4 m is observed around Lal Tappar only. The highest decadal rise of >4 m is not observed in Dehradun district according to the available data. Decadal decline in water level in the range of 0-2 m is observed in >70% of the Dehradun district. The decadal decline in the range of 2-4 m is observed as semicircular zone in and around Jhajra. The

decline in water levels >4m is observed around Harbanswala – Balliwala section.

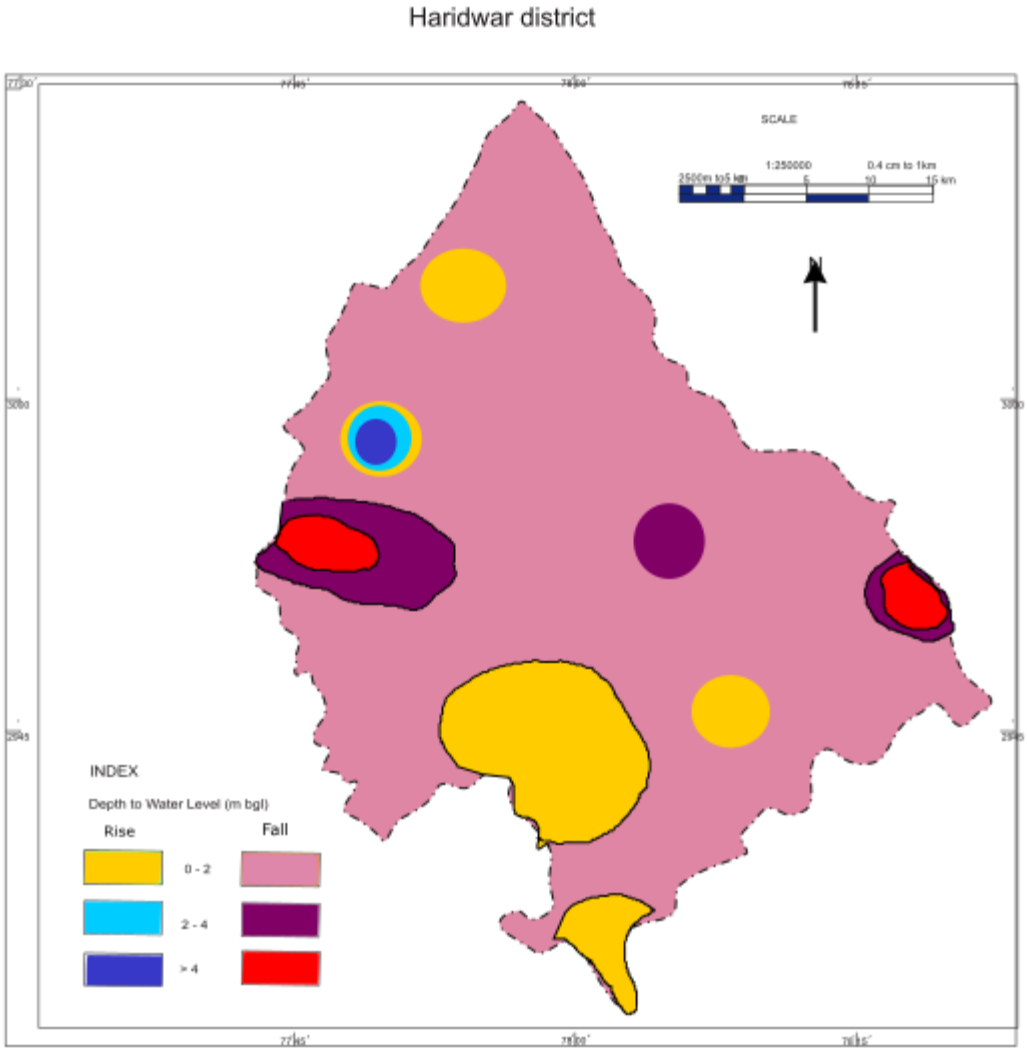


Figure 1712 Decadal Water Level Fluctuation Map (May 2007-2016 vs 2017), Haridwar District

A study of **Fig. 17** reveals that the minimum rise of 0-2 m is observed around Bhikampur – Dallawala - Goverdhanpur area in southern part of the district. Higher decadal rise of 2-4 m is observed around the Bandarjud – Rathura - Sahidwala Grant area and the highest decadal rise of >4 m is observed around Chudiala - Bhagwanpur. Decadal decline in water level in the range of 0-2 m is observed in more than 50% of the Haridwar District. Decline in the range of 2-4 m is observed around Gurkul Narsen and Sarai; whereas the decline in water levels >4m is observed around Kanpur and Laldhang only.

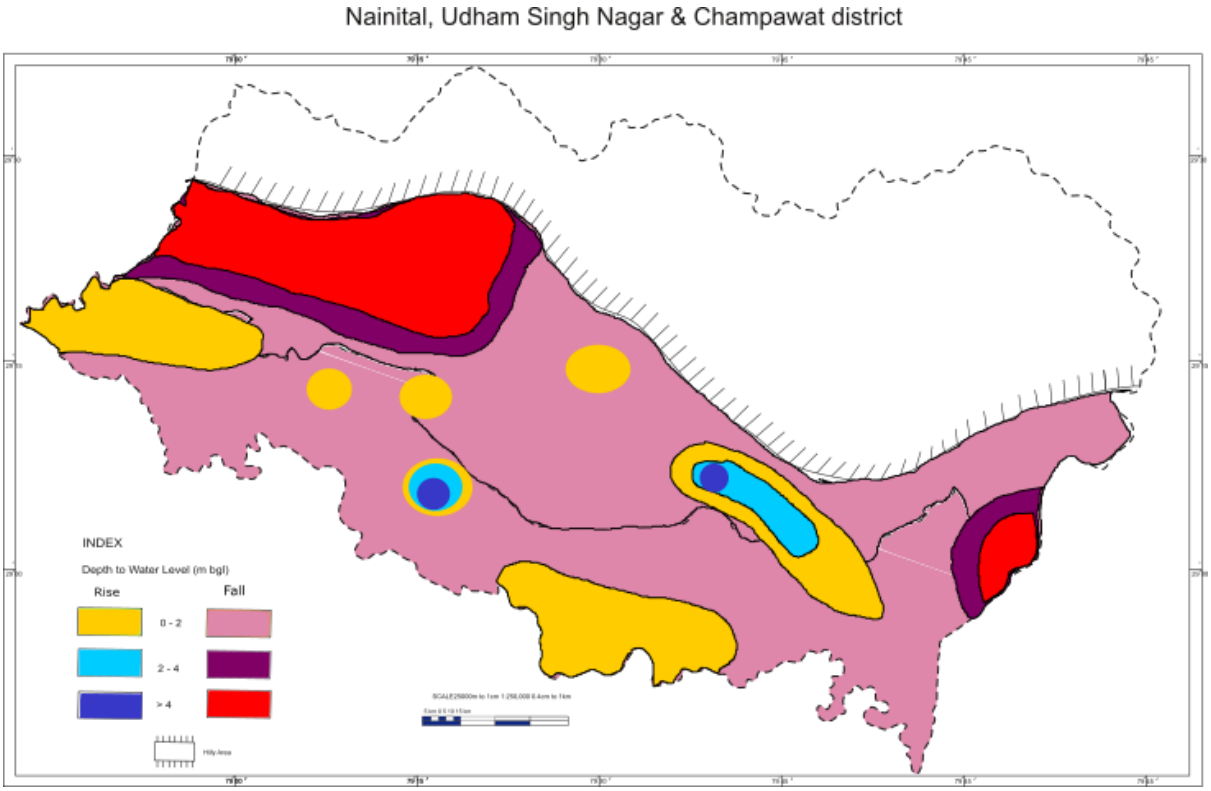


Figure 18 Decadal Water Level Fluctuation Map (May 2007-2016 vs 2017), US Nagar – Nainital - Champawat District

Interpretaton of **Fig. 18** has shown that decadal rise of 0-2 m is observed around Angadpurn - Paytrampur, Sultanpur patti- Sitarganj- Bara-Khatima-Nanak Mata section of Udham Singh Nagar district (in the Tarai zone), in Kathgodham in Nainital district falling in the Bhabar zone and around Bastia in Champawat district. Rise of 2-4 m is observed as outlier to the >4 m water level zone. Highest decadal rise of >4 m is observed in khatbass and Dhoniya in Nainital District. Decadal decline in water level in the range of 0-2 m is observed in majority of the areas in the entire Udham Singh Nagar-Nainital-Champawat section. Decadal decline in the range of 2-4 m is observed around Dhela, and Peeru Madara in Nainital district and Banbasa in Champawat District. Highest decadal decline of >4 m is observed around Jaspur (Udham Singh Nagar); Kaladhungi, in Nanital districts).

Table 12. Decadal Water Level Fluctuation (May 2007 –May 2016 Versus May 2017)

District	*No. of stations analyzed*	*Fluctuation (m)*				*Rise (m)*						*Decline (m)*					
		Rise		*Decline*		*0-2*		*2 to 4*		*>4*		*0-2*		*2 to 4*		*>4*	
		Min	*Max*	*Min*	*Max*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Dehradun	37	0.29	4.13	0.09	7.23	8	21.62	7	18.9189	3	8.11	10	27.03	6	16.22	3	8.11
Haridwar	32	0.08	8.01	0.03	6.14	10	31.25	0	0.00	1	3.13	16	50.00	3	9.38	2	6.25
Udham Singh Nagar	30	0.03	4.4	0.01	5.76	10	33.33	2	6.67	1	3.33	12	40.00	4	13.33	1	3.33
Nainital	6	0.74	25.43	0.59	18.12	1	16.67	0	0.00	1	16.67	0	0.00	1	16.67	3	50.00
Champawat	2	--	--	0.58	4.67	0	0.00	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
Pauri Garhwal	1	--	--	0.01		0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
Uttarkashi	6	0.44	18.01	0.25	1.6	2	33.33	0	0.00	2	33.33	2	33.33	0	0.00	0	0.00
Total	**114**	**0.03**	**25.43**	**0.01**	**18.12**	**31**	27.19	**9**	7.89	**8**	7.02	**42**	36.84	**14**	12.28	**10**	8.77

5.4.1.2 Water Level Fluctuation (August 2007-2016 versus August 2017)

Long-term water level data for 115 monitoring wells is analyzed and is shown in ***Table 13***. A perusal of the data shows that the minimum decadal rise is 0 m at Jhagarpuri in Udham Singh Nagar district whereas the maximum decadal rise is 11.84 m at Nanukhera Hand pump in Dehradun district. The minimum long-term decline in water level is 0.03 m at Shahidwala Grant in Haridwar district; whereas the maximum decadal decline of 9.26 m is recorded at Angadpur Hand Pump in Udham Singh Nagar district.

A perusal of **Table 13** indicates that the minimum long-term rise in the range of 0-2 m is observed in 34 monitoring wells (29.57% of the total number), whereas higher rise in the range of 2-4 m is observed in 7 wells (6.09% of total) and the highest rise of >4 m is observed in 8 monitoring wells (6.96% of total). The lowest long-term decline of water level in the range of 0-2 m is recorded in 39 monitoring wells, which is 33.91 % of the total number. Higher long-term decline in the range of 2-4 m is recorded by 10 wells (8.7 % of total) whereas the highest decline of >4 m is observed in 17 monitoring wells, which is 14.78% of the total number of wells.

The decadal water level fluctuation map for average (August 2006-2015) versus August 2016 is shown in ***Fig.19*** *(Dehradun, Section),* ***Fig.20*** *(Haridwar section)* and ***Fig. 21*** *(Nainital -Udham Singh Nagar-Champawat section)*.

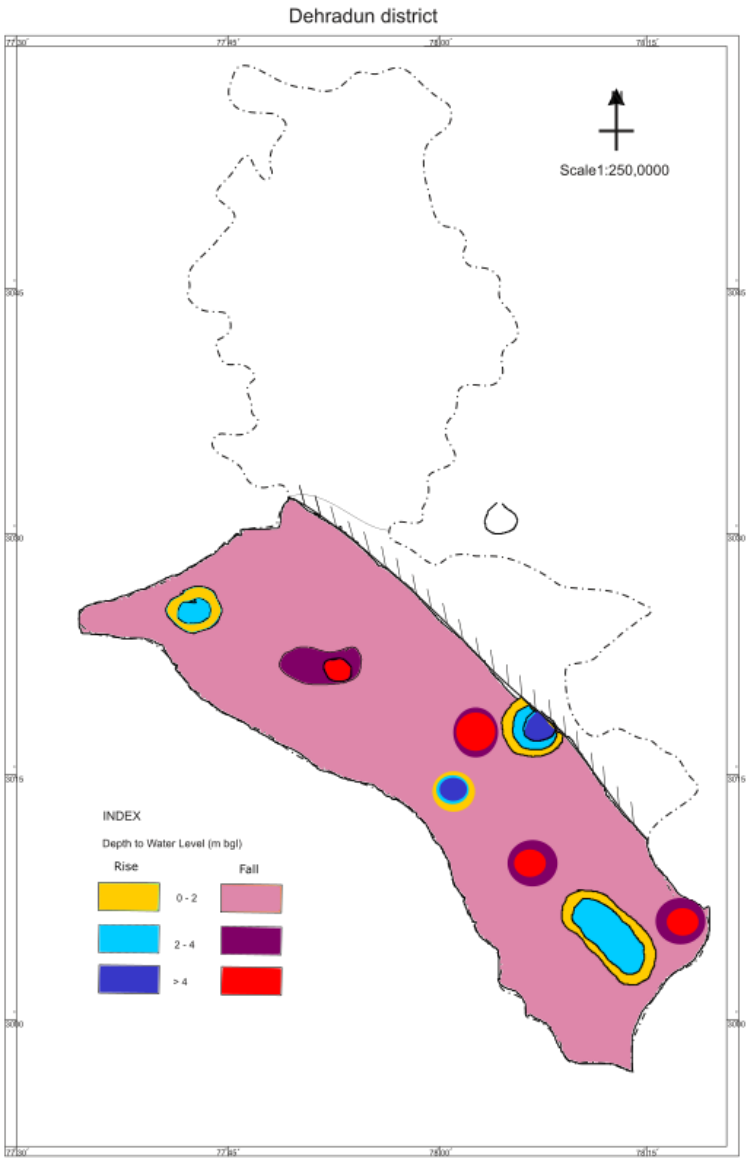


Figure 19 Decadal Water Level Fluctuation Map (August 2006-2015 vs 2016), Dehradun District

Visual interpretation of **Fig. 19** has shown that minimum decadal rise of 0-2 m is found in the isolated patch around Sabhawala and also as outlier to the 2 – 4m water level zone in eastern part of the district. Decadal rise of 2-4 m is observed around Bhaniawala and >4 m is observed around Nanukhera in Doon valley. The long-term decline of 0-2 m is observed in more than 70% of the Doon Valley. Higher decline of 2-4 m is observed as linear patche around Herbertpur-Redarpur section and as isolated patch around Laltappar. Long term deeper water level decline (>4m) is observed around the Shankarpur and Balliwala- Harbanswala section.

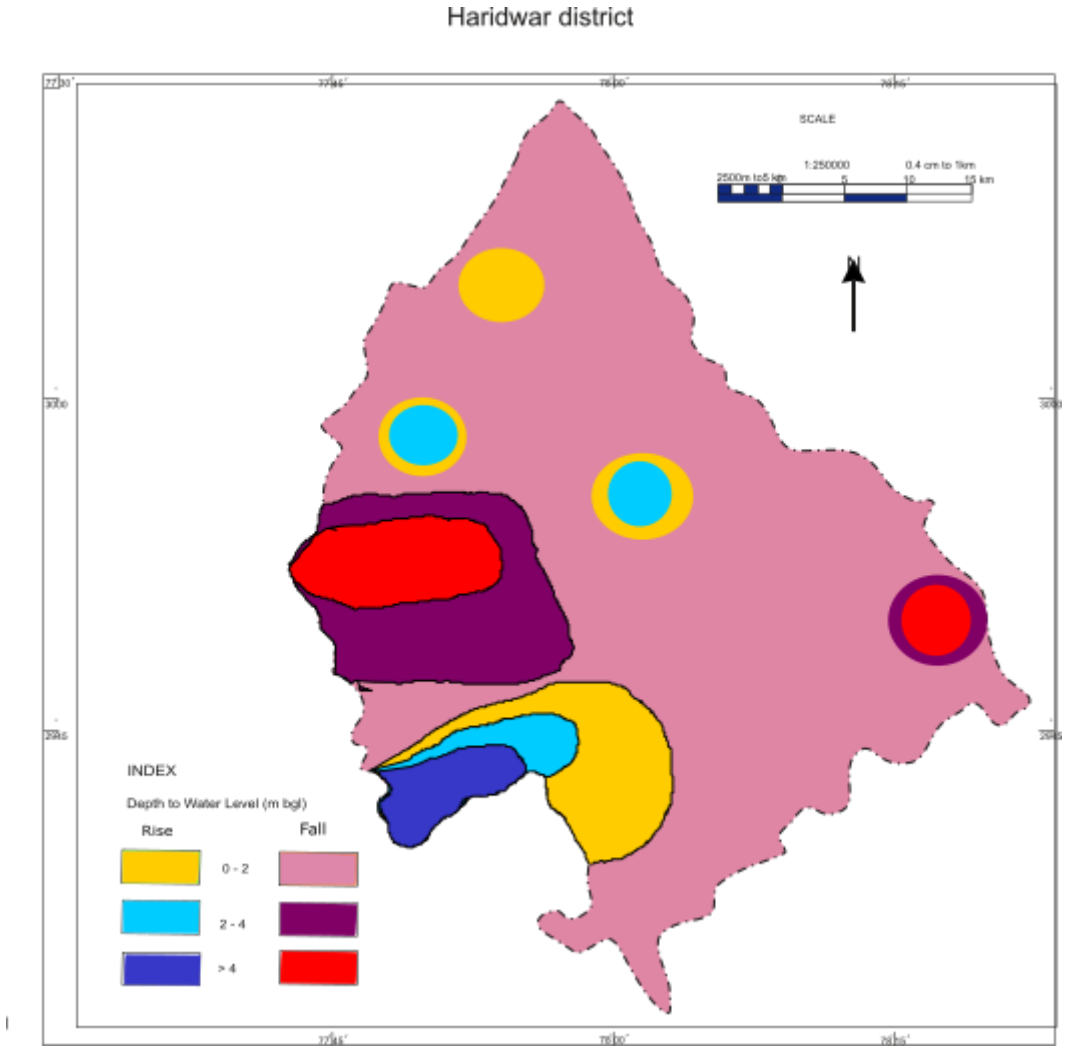


Figure 20 Decadal Water Level Fluctuation Map (August 2006-2015 vs 2016), Haridwar District

Visual interpretation of **Fig. 20** has shown that minimum decadal rise of 0-2 m is observed around the Sahidwala Grant – Bandarjud – Bhagwanpur and as elliptical patch around Bhikampur – Husainpur in southern part of the district. No monitoring wells shown the decadal rise in the range of 2-4m and >4m in Haridwar District. The minimum long-term decline of 0-2 m is observed in more than 70% of the Haridwar District. Higher decline of 2-4 m is observed around the Jhabrea. Long term deeper water level decline (>4m) is observed around the Baharabad – Sahidwala grant.

Visual interpretation of **Fig. 21** reveals that minimum decadal rise of 0-2 m is seen dominantly in south eastern part of section and also as isolated patches around Dhoniya in Nanital District and Jogipura (Udham Singh Nagar district). Higher decadal rise of 2-4 m is seen only in the isolated patch at Kamaria pakki in Udham Singh Nagar District and as outlier to the >4m water level zone. The highest decadal rise of >4 m is observed around Khatbass – Khatgodam in Nanital district and Bastia in Champawat District. The lowest decadal decline of 0-2 m is observed in major part of Tarai zone in Udham Singh Nagar district and the same situation is also seen in the Bhabhar Zone. Higher decadal decline of 2-4 m is observed around Patrampur – Bharatpur in Udham Singh Nagar district and Banbasa in Champawat district. The highest decadal decline of >4 m is observed around Jaspur (Udham Singh Nagar district); and Dhela (Nanital district).

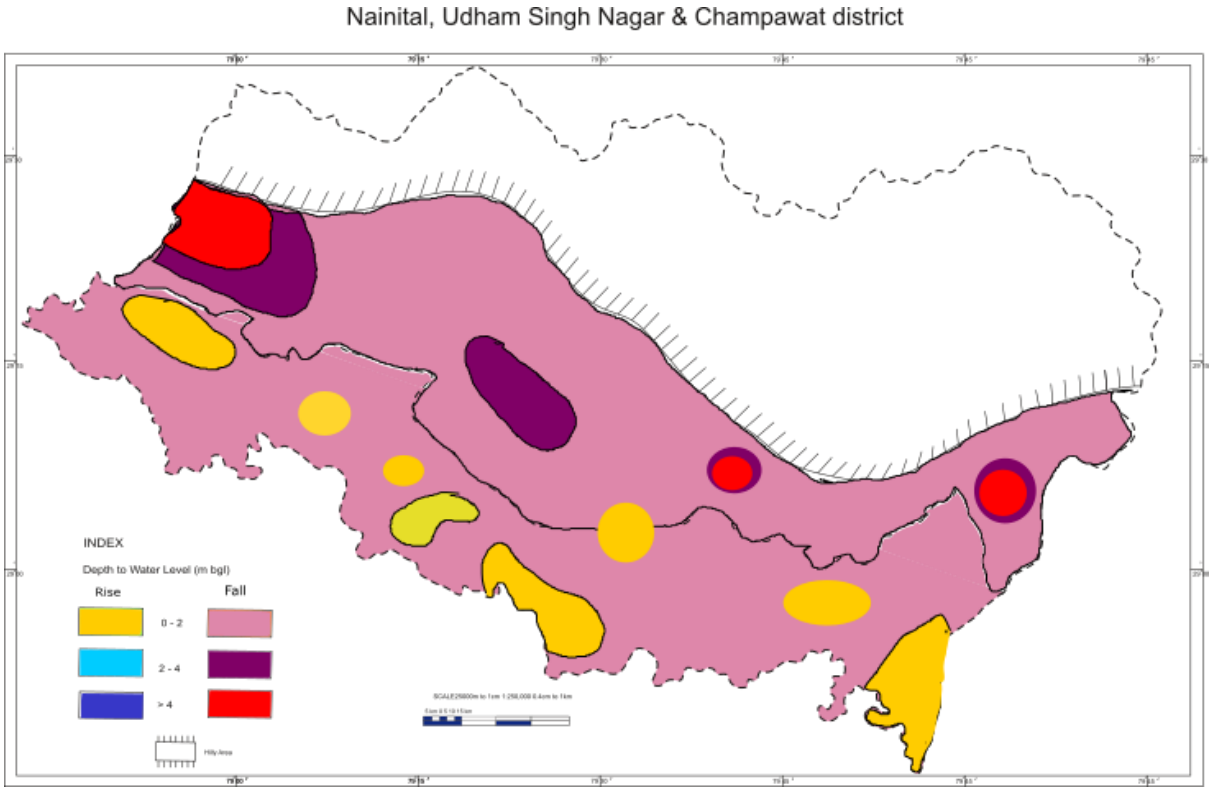


Figure 21 Decadal Water Level Fluctuation Map (August 2007-2016 vs 2017), US Nagar – Nainital - Champawat District

Table 13. Decadal Water Level Fluctuation (August 2007 –August 2016 versus August 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	38	0.62	11.84	0.17	8.32	3	7.89	4	10.5263	4	10.53	18	47.37	2	5.26	7	18.42
Haridwar	33	0.17	11.01	0.035	8.49	9	27.27	0	0.00	2	6.06	11	33.33	4	12.12	4	12.12
Udham Singh Nagar	31	0	3.61	0.35	9.2	18	58.06	1	3.23	0	0.00	6	19.35	3	9.68	3	9.68
Nainital	9	0.31	0.28	0.13	9.26	4	44.44	0	0.00	1	11.11	4	44.44	1	11.11	2	22.22
Champawat	3	3.64	5.44	6.47		0	0.00	1	33.33	1	33.33	0	0.00	0	0.00	1	33.33
Pauri Garhwal	1	3.61		--	--	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	**115**	**0**	**11.84**	**0.035**	**9.26**	**34**	29.57	**7**	6.09	**8**	6.96	**39**	33.91	**10**	8.70	**17**	14.78

5.4.1.3 Water Level Fluctuation (November 2007-2016 versus November 2017)

Long-term water level data for 136 monitoring wells is analyzed and is shown in ***Table 14***. A perusal of the data shows that the minimum decadal rise is 0.05 m at Bhagwanpur in Dehradun District while the maximum decadal rise is 15.39 m at Majra in Udham Singh Nagar District. The minimum decadal decline in water level is 0.004 m at Singhniwala in Dehradun district while the maximum decadal decline is 10.82 m at Tarla Nagal in Dehradun district. The table also indicates that 53 monitoring wells out of 136 (38.97 % of total) had shown decadal rise of 0-2 m, 6 monitoring wells (4.41 % of total) had shown rise of 2-4 m and 7 monitoring wells had shown the highest decadal rise of >4 m. As far as decadal decline in water level is concerned, 50 wells out of 136 (36.76 % of total) had recorded decadal decline in the range of 0-2 m, 12 monitoring wells (8.82% of total) had shown higher decadal decline of 2-4 m and 8 monitoring wells (5.88% of total) had shown the highest decadal decline of >4 m in Uttarakhand in the post-monsoon period.

The decadal water level fluctuation map for average (November 2006 -2015) versus November 2016 is shown in **Fig. 22 (***Dehradun District),* **Fig 23** *(Haridwar District)* and ***Fig. 24*** *(Nainital-Udham Singh Nagar-Champawat section)*.

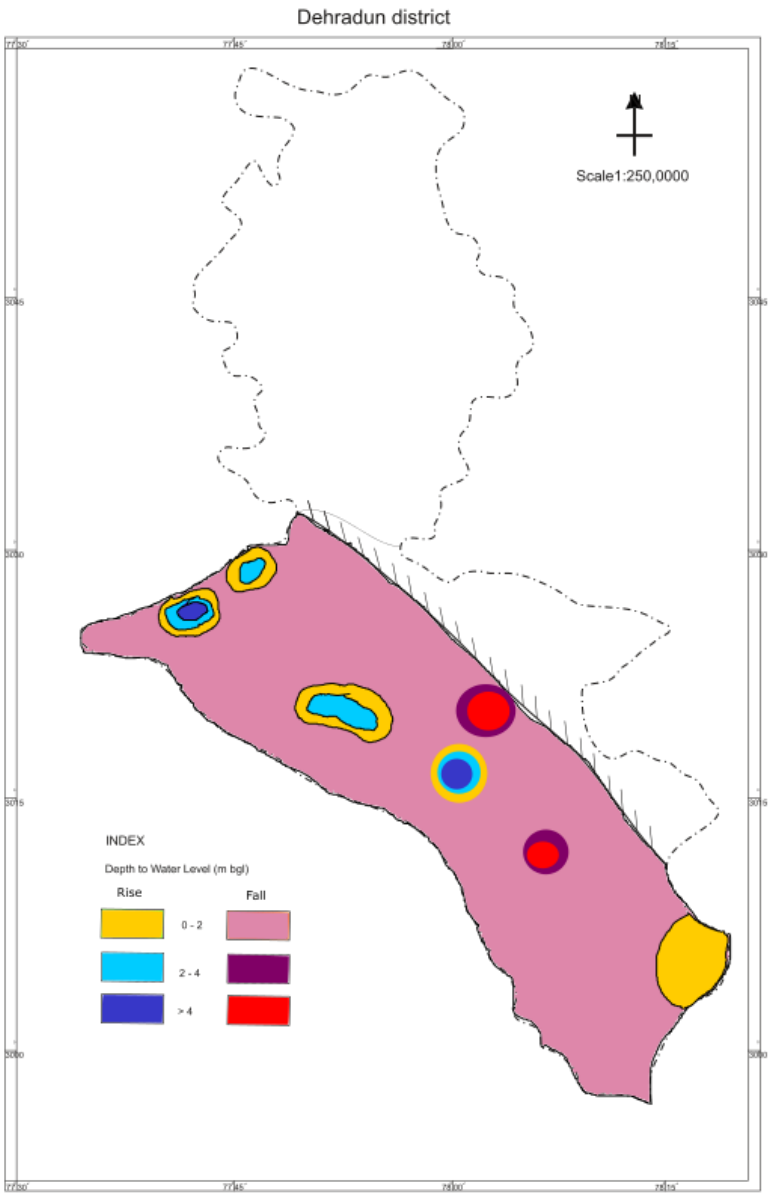


Figure 22 Decadal Water Level Fluctuation Map (November 2007-2016 vs 2017), Dehradun District

A perusal of **Fig. 22** reveals that minimum decadal rise of 0-2 m is observed as elliptical patch around Rampura – Nanda ki Chowki section and as outlier to the 2-4 m decadal rise water level zone in eastern part of the Doon valley. Higher decadal rise of 2-4 m and highest Rise >4m are observed around Bhaniawala only. The figure also shows that minimum decadal decline of 0-2 m is observed in more than 70% of the Doon valley. The decadal decline in the range of 2-4m is observed as outliers to the >4 m water level zone and as isolated patch at Lal Tappar. The highest decadal decline of >4 m is observed around Redarpur – Shanpur area and Harbanwala – Balliwala area.

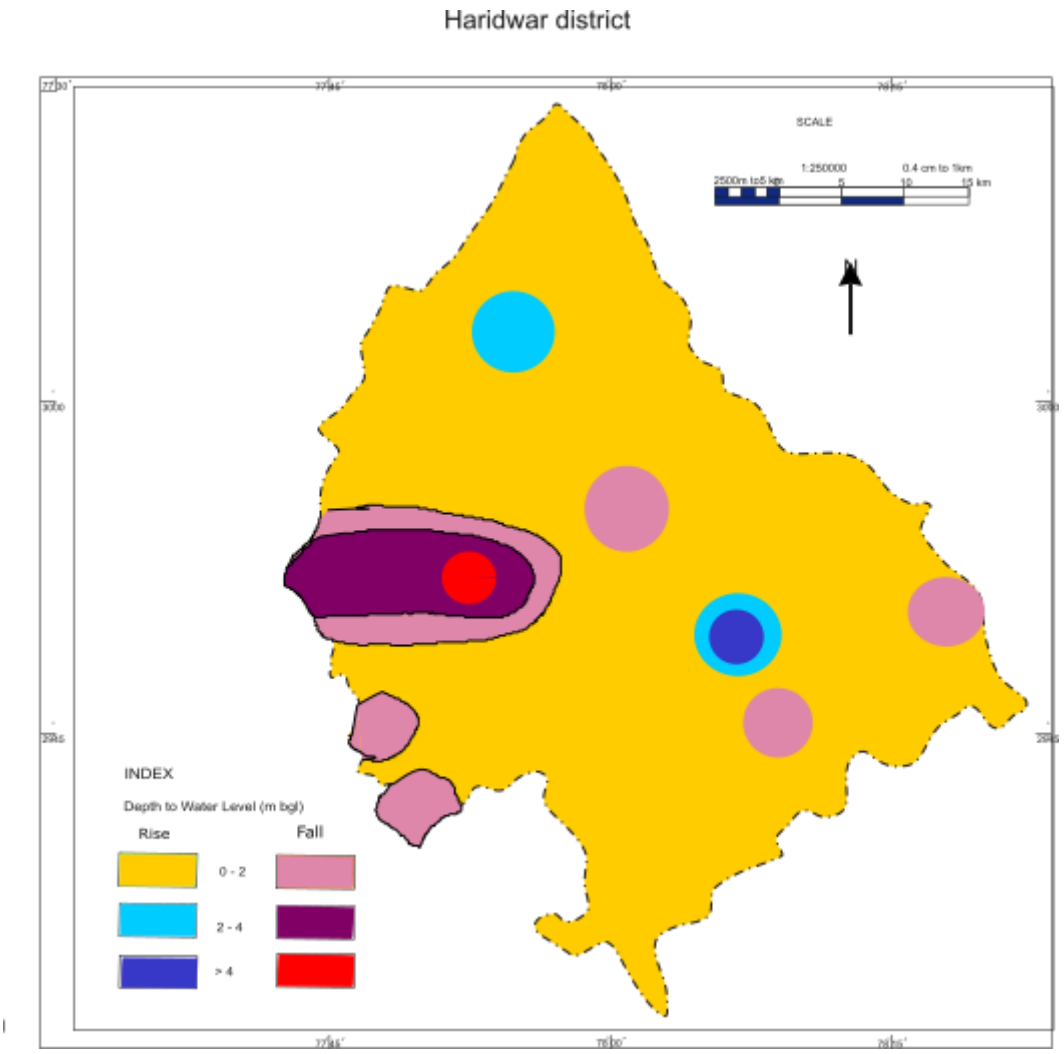


Figure 23 Decadal Water Level Fluctuation Map (November 2007-2016 vs 2017), Haridwar District

A perusal of **Fig. 23** reveals that minimum decadal rise of 0-2 m is observed in >70% parts of Haridwar District. Higher decadal rise of 2-4 m and highest decadal rise of >4 m are not seen in any area as per the available data. The minimum decadal decline of 0-2 m is observed as a circular zone covering Sarai – Rathura section and as linear patch around Sarai – Shapur Shitlakhera section in eastern part of the district. Higher decadal decline of 2-4 m is observed around Lakhnauta and the highest decadal decline of >4 m is observed around Laldhang and Imlikhera only.

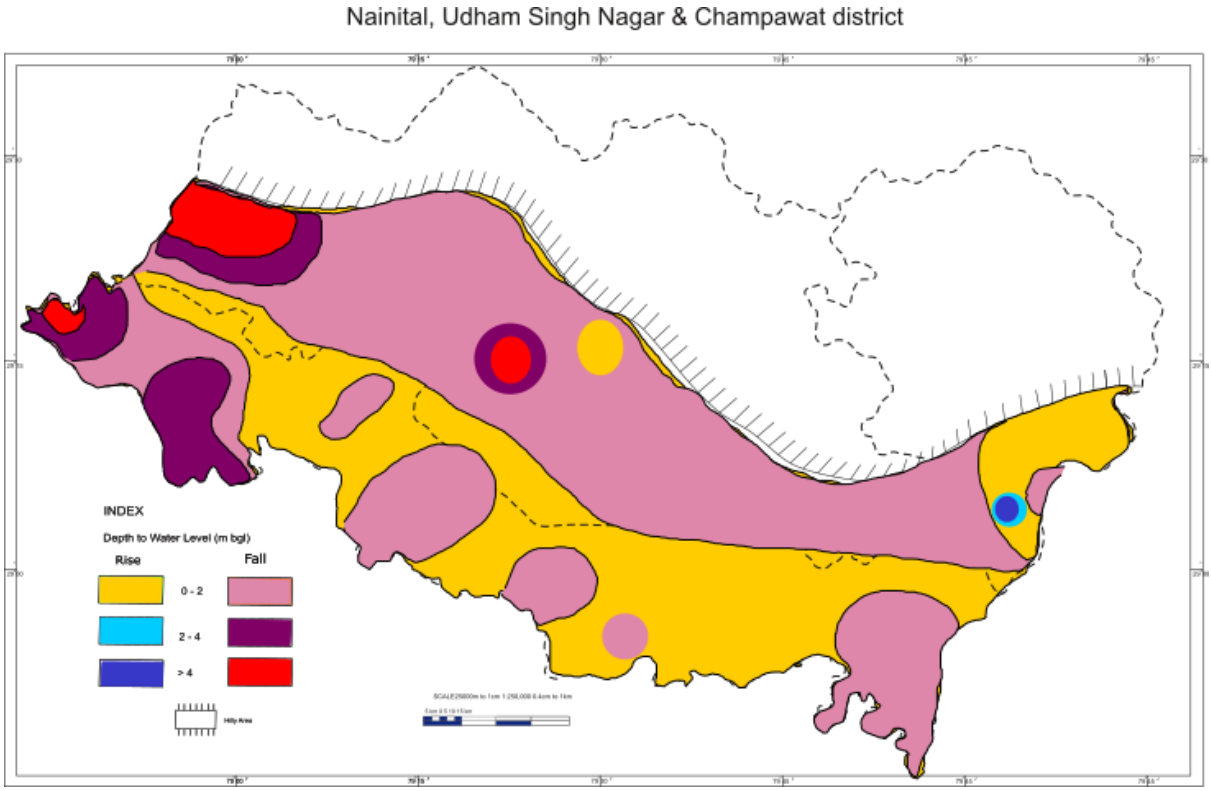


Figure 24 Decadal Water Level Fluctuation Map (November 2007-2016 vs 2017), US Nagar – Nainital - Champawat District

Visual interpretation of **Fig. 24** has shown that minimum decadal rise of 0-2 m is observed as isolated patches at Jogipura, Nanna Khera, Sitarganj in Udham Singh nagar and Kathgodham in Nainital District. Higher decadal rise of 2-4 m is seen as isolated patch at Chakarpur in Udham Singh Nagar District. The highest decadal rise of >4 m is observed around the Dhoniya in Nanital district. The minimum decadal decline of 0-2 m is observed in ~65% area of Udham Singh Nagar district falling in the Tarai zone and in ~70% area in the Bhabar zone of Nainital district. Higher decadal decline of 2-4 m is observed around Sultanpur Patti in Udham Singh Nagar district and around Khatbaas; also as concentric patch enclosing >4m zone in the north central and central part of the Bhabhar zone. The highest decadal decline of >4 m is observed around Jaspur in Udham Singh nagar district Dhela – Perru madara in Nanital district.

Table 14. Decadal Water Level Fluctuation (November 2007-November 2016 Versus November 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	39	0.1	15.39	0.00	10.82	12	30.77	2	5.12821	2	5.13	16	41.03	4	10.26	3	7.69
Haridwar	33	0.09	4	0.1	6.16	19	57.58	1	3.03	1	3.03	8	24.24	3	9.09	1	3.03
Udham Singh Nagar	42	0.05	2.1	0.01	8.84	19	45.24	1	2.38	0	0.00	18	42.86	3	7.14	1	2.38
Nainital	11	0.23	1.47	0.06	10.01	3	27.27	0	0.00	1	9.09	3	27.27	2	18.18	2	18.18
Champawat	4	1.22	5.41	0.45		0	0.00	2	50.00	1	25.00	1	25.00	0	0.00	0	0.00
Pauri Garhwal	1	--	--	1.39		0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
Uttarkashi	6	5.16	9.17	0.56	5.77	0	0.00	0	0.00	2	33.33	3	50.00	0	0.00	1	16.67
Total	**136**	**0.05**	**15.39**	**0.00**	**10.82**	**53**	38.97	**6**	4.41	**7**	5.15	**50**	36.76	**12**	8.82	**8**	5.88

5.4.1.4 Water Level Fluctuation (January 2008-2017 Versus January 2018)

Decadal (long-term) water level data for 142 ground water monitoring wells is analyzed and is given in ***Table 15***. Analysis of the data reveals that the lowest decadal rise is 0.06 m at Gangapur in Udham Singh Nagar District whereas the highest decadal rise is 20.12 m at Chiniyalisaur in Udham Singh Nagar District. As far as decadal decline in water level is concerned, the highest is 15.73 m at Tarla Nagal in Dehradun district while the lowest is 0.02m at Landhaura in Haridwar district.

A perusal of the table also indicates that out of 142 monitoring wells, 42 wells (29.58% of the total number) had shown the minimum decadal rise in the range 0-2 m, 7 wells (4.93% of the total number) of monitoring wells had shown a higher rise in the range 2-4 m while only 5 well (4.93 % of total) had shown the highest decadal rise of >4 m. The minimum decadal decline in the range of 0-2 m is shown by 59 wells (41.55% of total) while 13 wells (9.15%) had shown higher decadal rise of 2-4 m. 16 monitoring well (11.27 %) has recorded the highest decadal decline (>4 m) in Uttarakhand State.

The decadal water level fluctuation map for average (January 2007-2016 versus January 2017) is shown in ***Fig. 25*** *(Dehradun section), Fig.26 (Haridwar section)* and ***Fig. 27*** *(Nainital-Udham Singh Nagar-Champawat section)*.

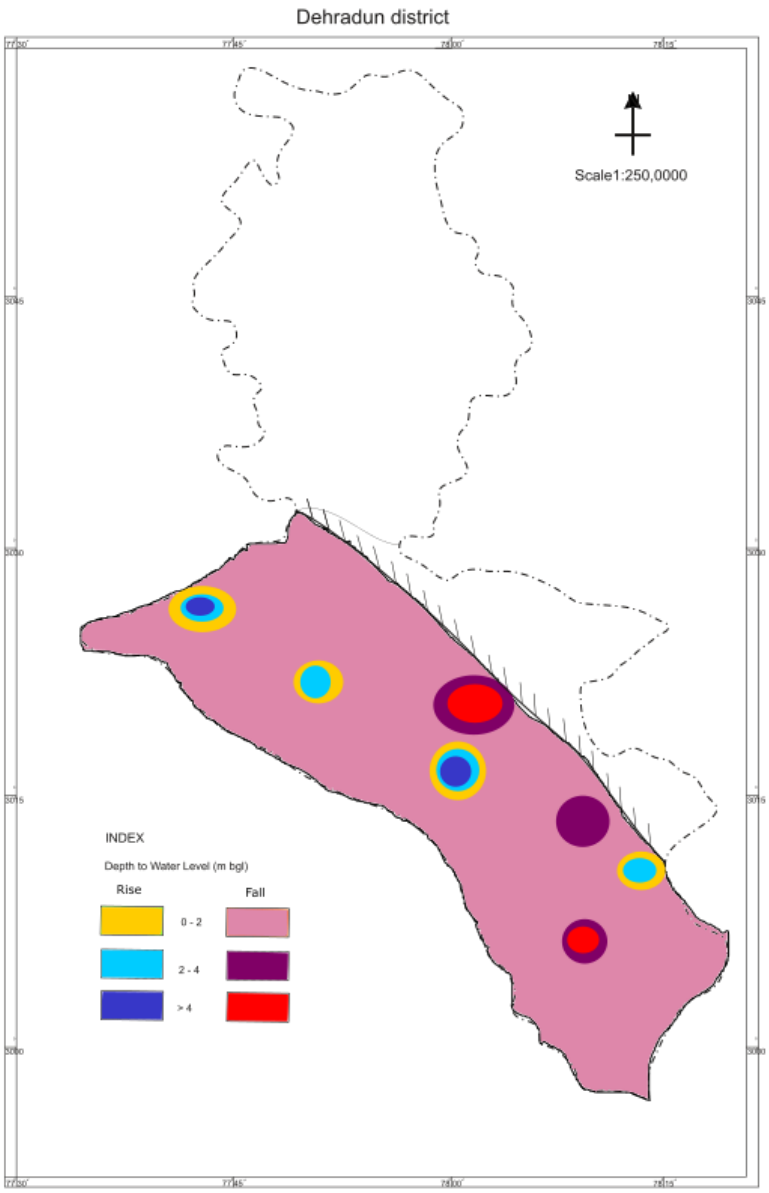


Figure 13 Decadal Water Level Fluctuation Map (January 2007-2016 vs 2017), Dehradun District

A perusal of **Fig. 25** (Dehradun District) reveals that minimum decadal rise of 0-2 m is observed as isolated patch around Nanukhera and as outlier to the 2-4m water level (decadal rise) zone around Ramgarh. Higher decadal rise of 2-4m is observed around rampura – Singhniwala section; whereas no area recorded decadal rise of >4m is as per the available data. The minimum decadal decline of 0-2 m is observed in isolated patches at Judli – Herbertpur – Redarpur and Lal Tappar. The decadal decline in the range of 2-4 m is observed en-circling the 0-2m zone in Doon valley. The decadal decline in the range of >4m is observed in majority of the Doon valley.

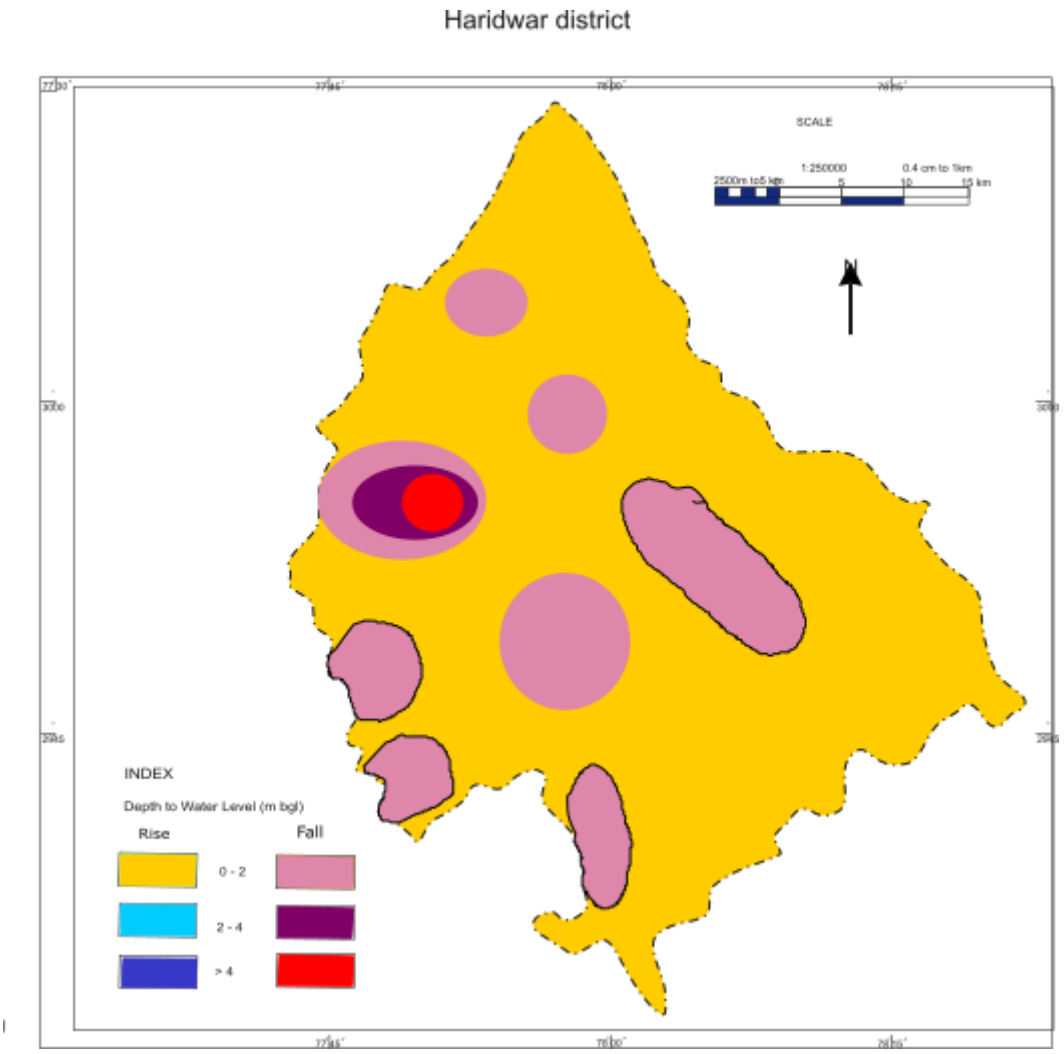


Figure 14 Decadal Water Level Fluctuation Map (January 2007-2016 vs 2017), Haridwar District

A perusal of **Fig. 26** (Haridwar District) reveals that minimum decadal rise of 0-2 m is observed around Sahidwala grant – Iqbalpur – Husainpur – Dallawala in the form a broad zone extending from western part of the district covering central part and reaching till southern part of the district. Higher decadal rise of 2-4 m is observed around Bhikampur only; whereas no monitoring wells has recorded decadal decline of >4m in the Haridwar district. The decadal decline in the range of 0-2m is observed as linear patch covering BandarJud – Sarai – Dhanpura – Shahpur – Shitlakhera and also in south western part of the district. The decadal decline in the range of >4m is observed at Laldhang only as per available data.

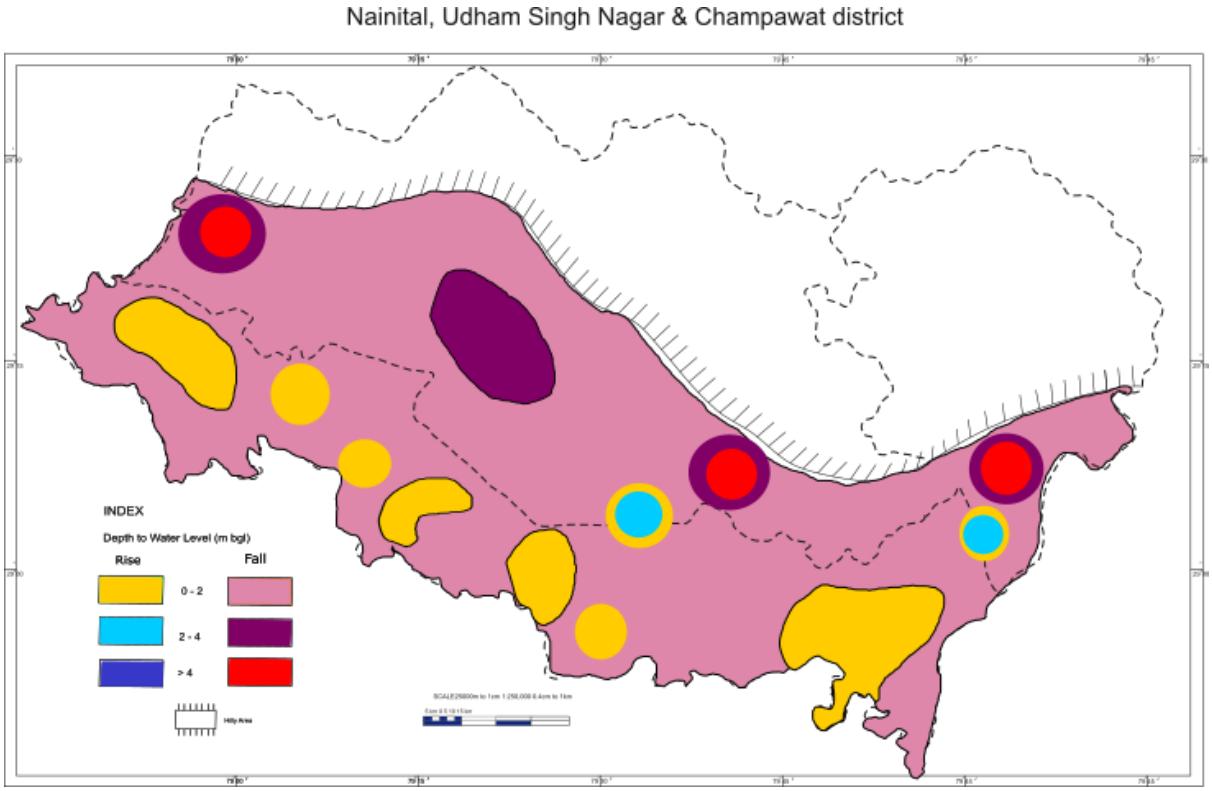


Figure 15 Decadal Water Level Fluctuation Map (January 2008-2017 vs 2018), US Nagar – Nainital - Champawat District

Visual interpretation of **Fig. 27***(Nainital-Udham Singh Nagar-Champawat section)* has shown that minimum decadal rise of 0-2 m is observed as long narrow patch around Bara – Gangapur – Beria Daulat – Bana Khera and as isolated patch at Nanak Mata (Udham singh Nagar district) and Banbasa (Champawat district). Higher decadal rise of 2-4 m is observed en-circling the Highest decadal rise >4m zone around kathgodham in Nanital District and as isolated patch around Jogipura in Udham Singh Nagar District. The minimum decadal decline of 0-2 m is observed in Northern and central Part of Tarai Zone, also in major parts of Bhabhar zone. Higher decadal decline of 2-4 m is observed Jaspur - Angadpur – Patrampur (Udham Singh Nagar District) and Peeru Madara (Nainital district). Whereas the highest decadal decline of >4 m is observed around Dhoniya, Khatbass in Nainital District and Bastia in Champawat district.

Table 15. Decadal Water Level Fluctuation (January 2008-January 2017 Versus January 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	42	0.14	10.86	0.04	15.73	6	14.29	5	11.9048	3	7.14	13	30.95	8	19.05	7	16.67
Haridwar	34	1.78	0.008	0.02	6.62	18	52.94	0	0.00	0	0.00	14	41.18	1	2.94	1	2.94
Udham Singh Nagar	43	1.62	0.038	0.006	8.73	15	34.88	0	0.00	0	0.00	24	55.81	1	2.33	3	6.98
Nainital	12	0.06	2.09	0.035	11.35	1	8.33	1	8.33	0	0.00	5	41.67	3	25.00	2	16.67
Champawat	3	2.4		0.37	6.4	0	0.00	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
Pauri Garhwal	1	--	--	0.18		0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
Uttarkashi	7	0.38	20.12	0.32	10.6	2	28.57	0	0.00	2	28.57	1	14.29	0	0.00	2	28.57
Total	**142**	**0.06**	**20.12**	**0.02**	**15.73**	**42**	29.58	**7**	4.93	**5**	3.52	**59**	41.55	**13**	9.15	**16**	11.27

5.4.2 YEARLY WATER LEVEL FLUCTUATION

5.4.2.1 Water Level Fluctuation (May 2016 versus May 2017)

The analysis of data for 141 Ground Water Monitoring Wells for May 2016 versus May 2017 is given in ***Table 16.*** A perusal of the table shows that the minimum annual rise in water level is 0 m at Majhola in Dehradun district while the maximum annual rise is 7.01 m at Majra, Udham Singh Nagar district. The minimum annual decline in ground water level is 0.001 m at Bairanjaniya in Udham Singh Nagar district while the maximum annual decline is 7.8 m at Peeru Madara in Nainital district.

A perusal of ***Table 16*** reveals that out of 141 monitoring wells 49 (34.75% of total) has shown minimum rise in the range 0-2 m whereas higher rise of 2-4 m is shown by 8 monitoring wells (5.67% of the total) and the highest rise of >4 m is recorded by 3 monitoring wells (2.13%) for calculating the annual fluctuation in ground water level for the pre-monsoon period. The minimum decadal decline in the range of 0-2 m is shown by 64 out of 141 monitoring wells (45.39% of the total number) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is recorded by 8 monitoring wells (5.67% of total) whereas the highest decline of >4 m is recorded by 9 monitoring wells (6.38% of the total number).

The annual water level fluctuation map during the period May 2015 versus May 2016 has been shown in ***Fig. 28*** *(Dehradun District), Figure. 29 (Haridwar section)* and ***Fig. 30*** *(Nainital- Udham Singh Nagar-Champawat section)*.

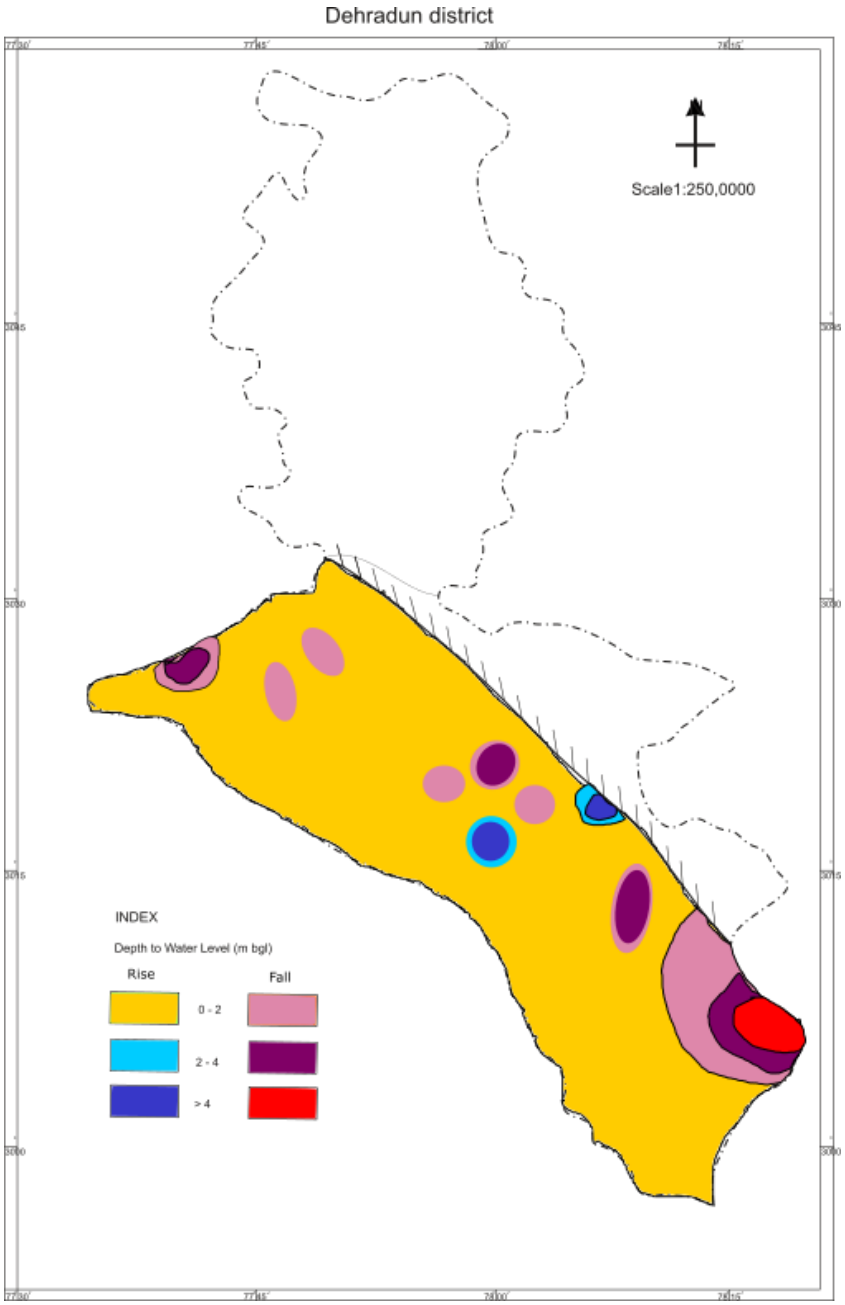


Figure 16 Annual Water Level Fluctuation Map (May 2015 vs 2016), Dehradun District

Fig. 28 (Dehradun District) reveals that minimum Annual rise of 0-2 m is observed as long narrow circular extending from western oart of Doon valley extending upto central part of the valley, covering areas Herbertpur, majra, Redarpur. This zone is also observed as isolated patch at lal Tappar. Higher annual rise of 2-4 m is observed en-circling the 0-2m zone in Doon valley. The highest annual rise of >4 m is observed in more than 50% parts of the Doon valley.The minimum annual decline of 0-2 m is observed in the form of U shaped band in central part of valley (Judli – Sabhawal;a – Shankarpur – Jhajra – Balliwala – Nanukhera section) of Dehradun district. Higher annual decline of 2-4 m is observed around Rampura and the highest annual decline of >4 m is observed around Harbanswala as per available data.

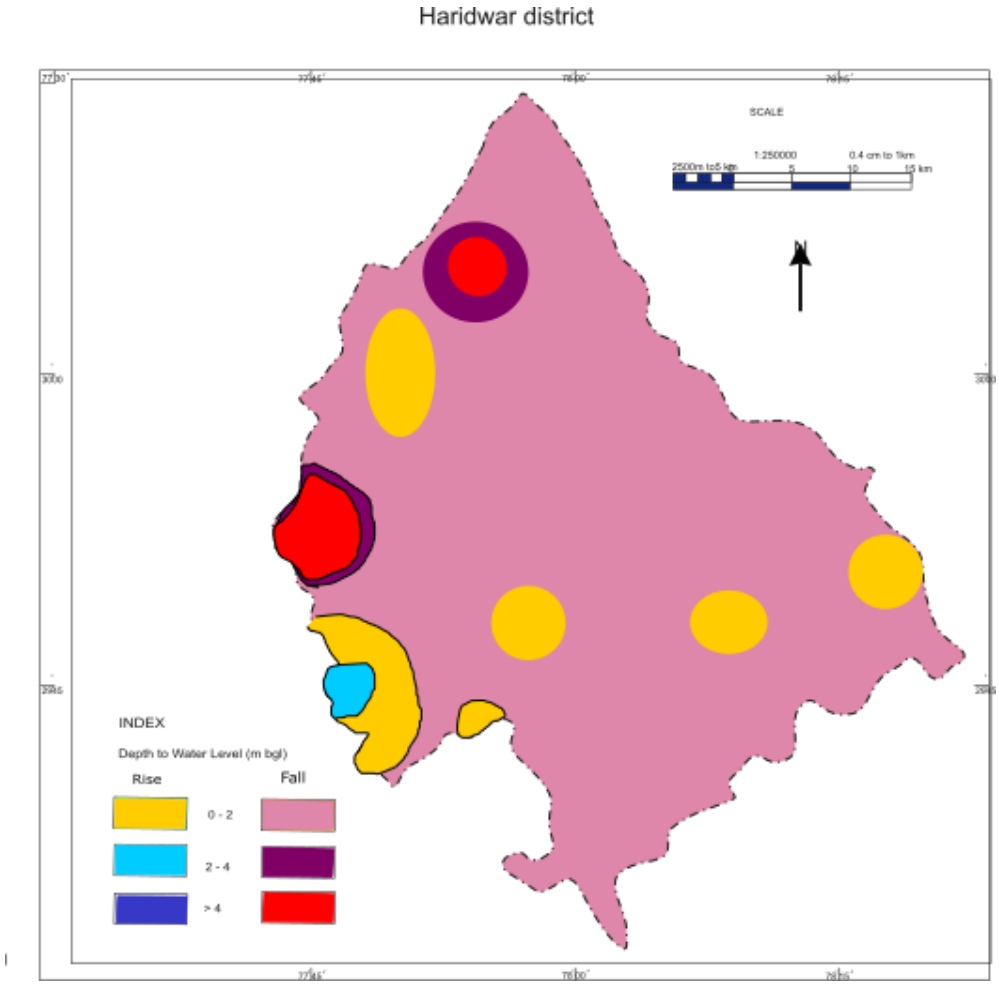


Figure 17 Annual Water Level Fluctuation Map (May 2015 vs 2016), Haridwar District

A perusal of **Fig. 29** (Haridwar District) shows that the more than 50% area is recorded with the water level in the range of 0-2 m. The annual rise of 2-4 m is observed as outlier to the >4m water level zone around Iqbalpur – Rathura. The >4m water level zone is observed around Imlikhera – Bhagwanpur – Chudiala and as isolated patch around Bhikampur. The minimum annual decline of 0-2 m is observed as semicircular patch in eastern part of the district enclosing the 2-4m water level zone; as isolated patche around Sahidwala grant. Higher annual decline of 2-4 m is observed around Manglaur. The highest annual decline of >4 m is observed around Sarai and Lakhnauta in the district.

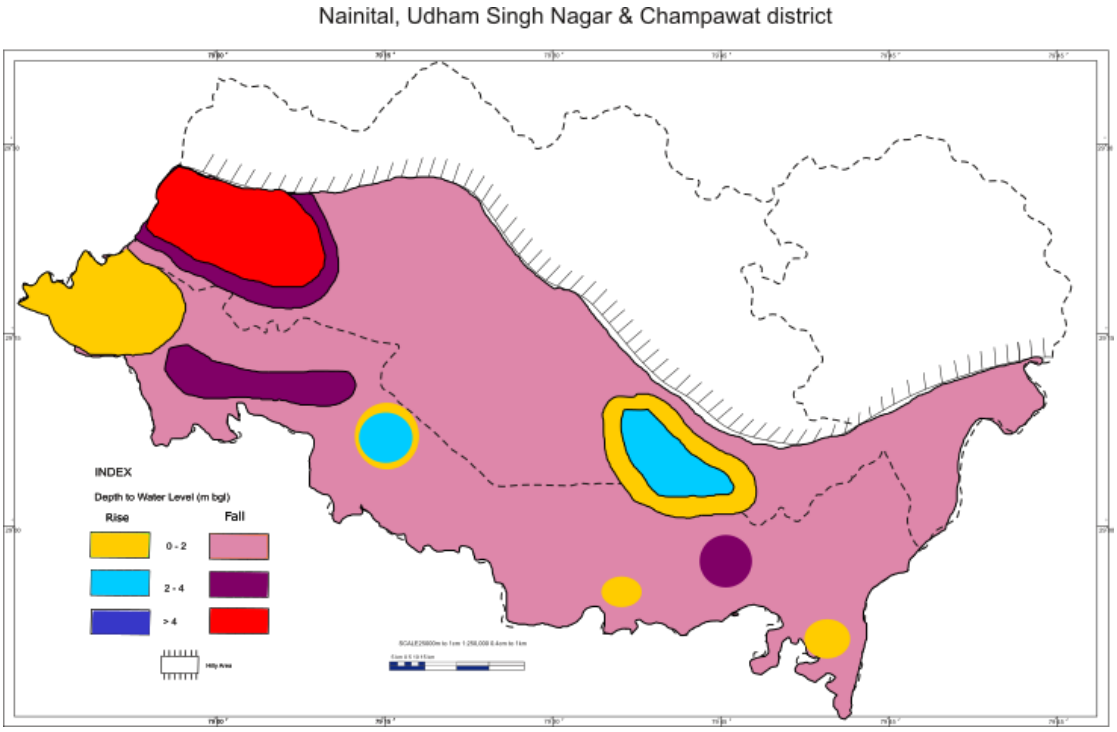


Figure 30 Annual Water Level Fluctuation Map (May 2015 vs 2016), US Nagar – Nainital - Champawat District

A study of **Fig. 30** shows that during the pre monsoon period, the minimum annual rise of 0-2 m is observed in major part of Tarai and Bhabhar Zone. Higher annual rise of 2-4 m is observed as outlier to the >4m water level annual rise zone. The highest annual rise of >4 m is observed around Dhoniya – Dhela and Khatbass in Nanital district; and around Bastia in Champawat District. The lowest pre monsoon annual decline of 0-2 m is observed as isolated patches around Kathgodham in Bhabhar Zone and in south eastern part of the Tarai Zone. Higher annual decline of 2-4 m is observed encircling the >4m zone around Jaspur in Udham Singh Nagar District.

Table 16. Annual Water Level Fluctuation (May 2016 Versus May 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	45	0.06	7.01	0.05	4.31	22	48.89	4	8.88889	2	4.44	11	24.44	4	8.89	2	4.44
Haridwar	37	0.06	2.67	0.03	6.82	16	43.24	1	2.70	0	0.00	17	45.95	0	0.00	3	8.11
Udham Singh Nagar	42	0	2.15	0.01	3.4	5	11.90	2	4.76	0	0.00	31	73.81	4	9.52	0	0.00
Nainital	7	3.55		0.07	7.8	0	0.00	1	14.29	0	0.00	3	42.86	0	0.00	3	42.86
Champawat	2	--	--	0.32	0.51	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Pauri Garhwal	1	--	--	0.63		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	7	0.08	8.93	0.1	6.56	3	42.86	0	0.00	1	14.29	2	28.57	0	0.00	1	14.29
Total	**141**	**0**	**7.01**	**0.01**	**7.8**	**49**	34.75	**8**	5.67	**3**	2.13	**64**	45.39	**8**	5.67	**9**	6.38

5.4.2.2 Water Level Fluctuation (August 2016 versus August 2017)

The analysis of annual water level fluctuation data for 148 Ground Water Monitoring Wells for the periods August 2016 and August 2017 is given in ***Table 17.*** Analysis of the fluctuation data indicates that the minimum annual rise of 0.02 m is observed at Jaswawala, Haridwar district. The maximum annual rise of 10.59 m is observed at Chilkia in Nainital district. The lowest annual decline is 0.01 m at Uttarkashi in Uttarkashi district, whereas the highest decline is 6.4 m at Khaat Baans in Nainital district.

Analysis of the fluctuation data has indicated that out of 148 monitoring wells, 64 wells (43.24% of total) had shown an annual rise in the range 0-2 m while higher rise of 2-4 m is observed in 9 monitoring well (6.08% of total). The highest rise in the range >4 m is recorded by 3 monitoring wells, which is 2.03% of the total number of wells. It is also seen that majority of monitoring wells (62 out of 148, 41.89% of total) had recorded annual decline in the range of 0-2 m. Higher annual decline of 2-4 m is shown by 6 monitoring wells (4.05% of total) while the highest decline of >4 m is shown by 4 monitoring wells, which is 2.7% of the total number of wells.

The annual water level fluctuation map during the period August 2015 versus August 2016 is shown in ***Fig. 31*** *(Dehradun section),* ***Fig. 32*** *(Haridwar section)* and ***Fig. 33*** *(Nainital-Udham Singh Nagar-Champawat section)*.

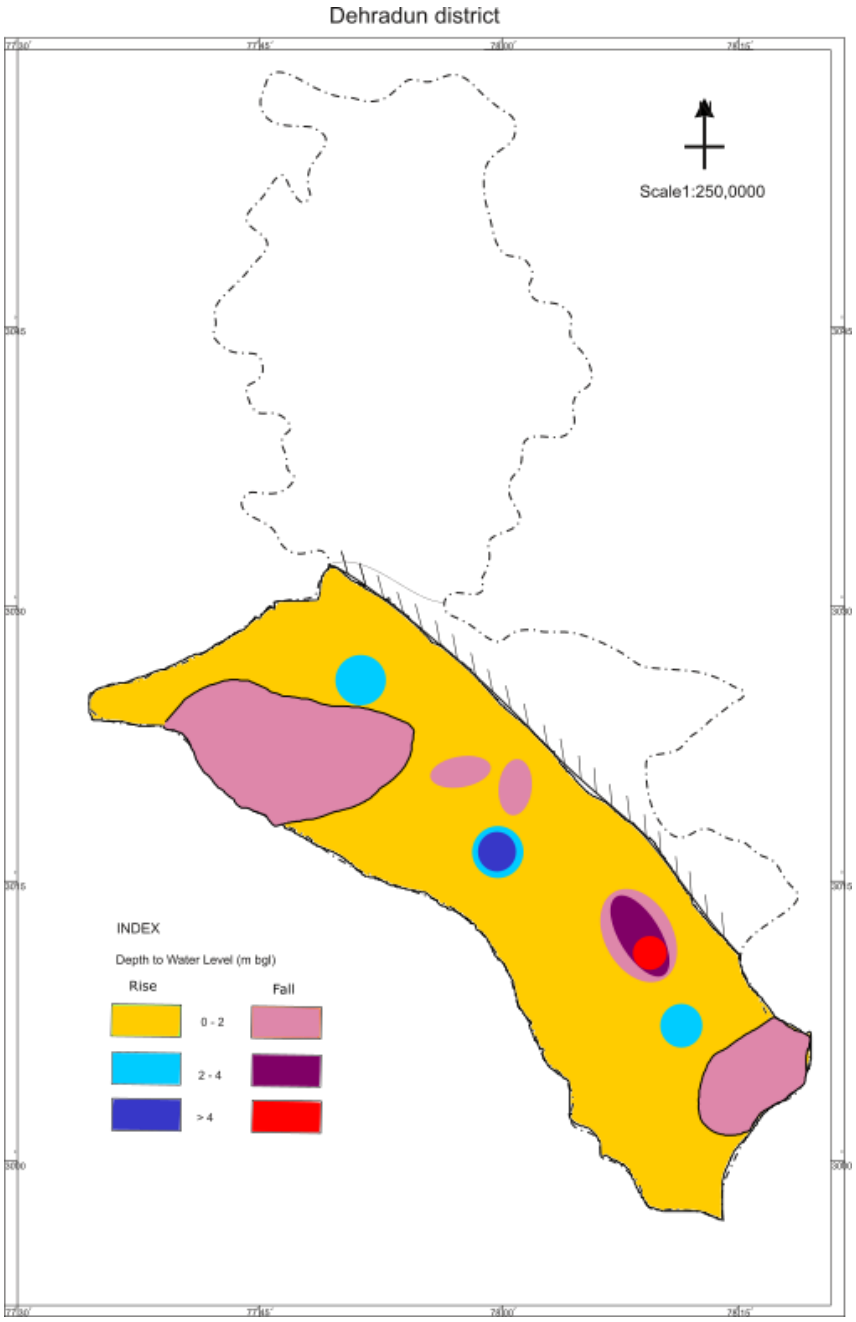


Figure 31 Annual Water Level Fluctuation Map (August 2015 vs 2016), Dehradun District

A perusal of Fig. 31 indicates that minimum annual rise of 0-2 m is seen in Southeastern part of the Doon valley and as isolated patches around Sabhawala, Rampura. The higher annual rise of 2-4 m is observed as zone en-circling the > 4m water level zone, whereas the highest annual rise of >4 m is observed as long patch covering nanukhera – Bhaniawala section. The minimum annual decline of 0-2 m is observed in more than 70% area of the valley whereas the Higher annual decline of 2-4 m is observed Harbanswala The highest annual decline of >4 m is observed as isolated patches around Balliwala.

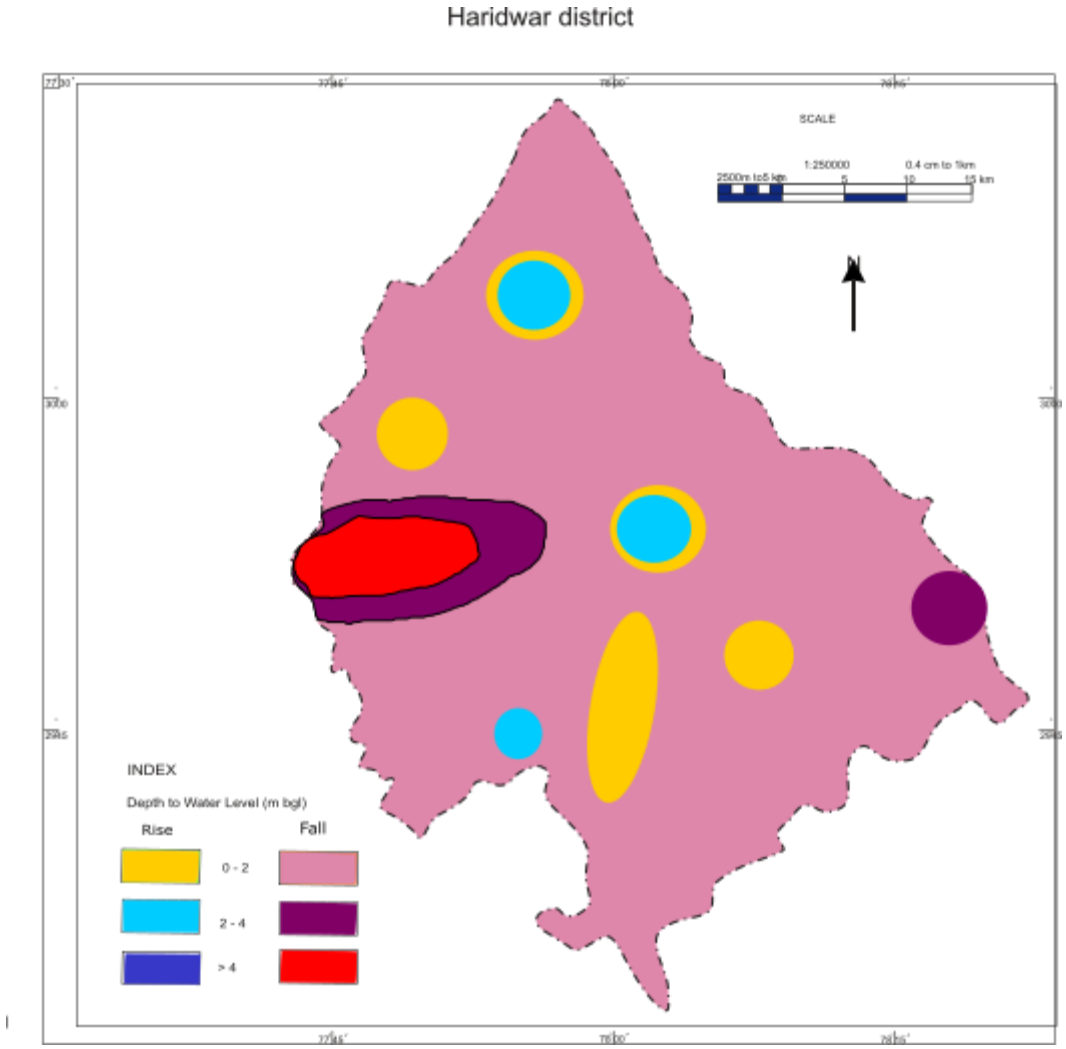


Figure 32 Annual Water Level Fluctuation Map (August 2015 vs 2016), Haridwar District

A perusal of **Fig. 32** indicates that minimum annual rise of 0-2 m is observed in major parts of the district. The 2-4m water level zone is observed as isolated patch around Bandarjud. The highest annual rise of >4 m is observed as around Laldhang. The minimum annual decline of 0-2 m is observed as patches around Bahadrabad, Shapur Shitlakhera, Gurkul Narsen and Dallawala. Higher annual decline of 2-4 m is observed as inlier around Imlikhera and Nizampur to the 0-2m decline water level zone. The highest annual decline of >4 m is observed around the Jhabrera and Lakhnauta.

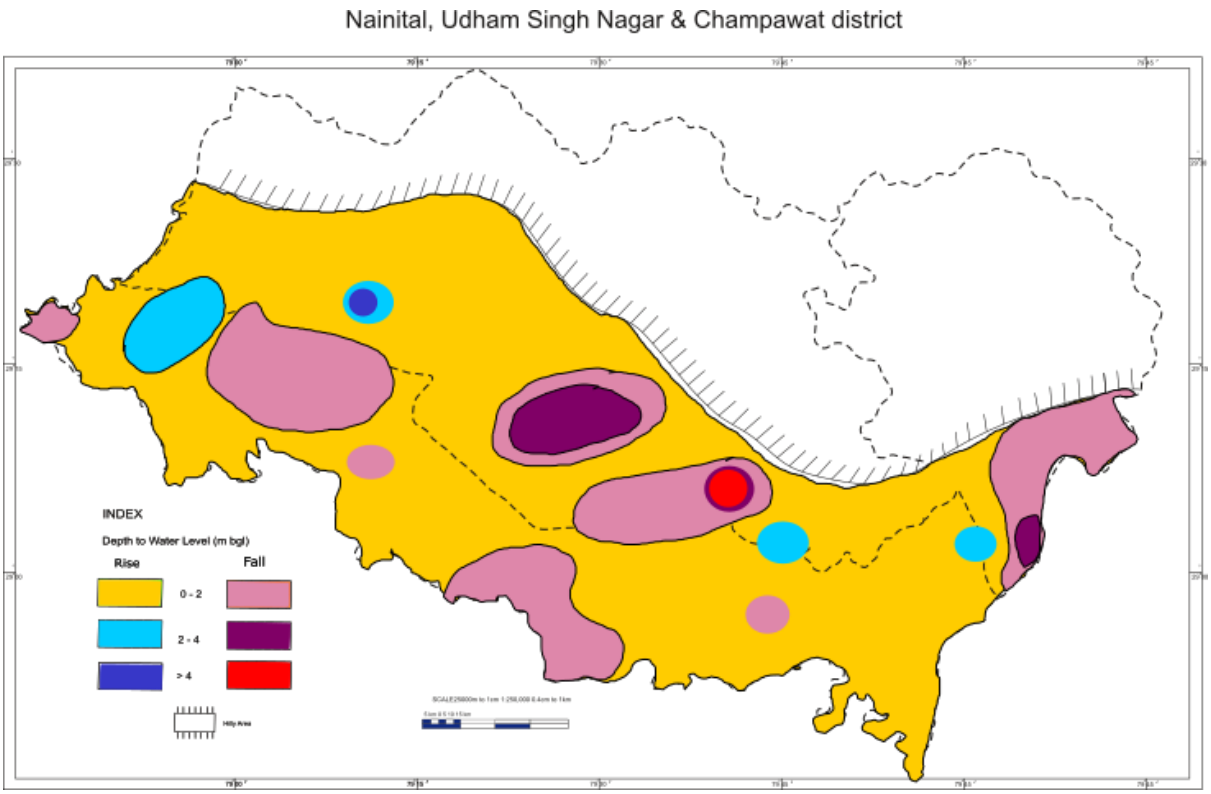


Figure 33 Annual Water Level Fluctuation Map (August 2015 vs 2016), US Nagar – Nainital - Champawat District

A perusal of **Fig. 33** indicates that minimum annual rise of 0-2 m is observed around Beria Daulat – Pathar chatta – Shantipuri – Sitarganj in Udham Singh Nagar District and along Kaladhungi in Nanital district. The higher annual rise of 2-4 m is observed around Khatgodham in Nanital district and Majhola in Udham Singh Nagar District. The highest annual rise of >4 m is observed around Khatbass (Nainital District) and Bastia (Champawat district). The minimum annual decline of 0-2 m is observed in central and eastern part of Bhabhar zone and in northern part of Tarai Zone. Higher annual decline of 2-4 m is observed as outlier to the >4m annual decline around Peeru Madara in Nainital district.

Table 17. Annual Water Level Fluctuation (August 2016 versus August 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	46	0.02	6.97	0.04	5.84	21	45.65	3	6.52174	2	4.35	18	39.13	1	2.17	1	2.17
Haridwar	37	0.02	2.48	0.05	4.72	9	24.32	2	5.41	0	0.00	22	59.46	2	5.41	2	5.41
Udham Singh Nagar	44	0.06	2.68	0.1	1.5	26	59.09	3	6.82	0	0.00	15	34.09	0	0.00	0	0.00
Nainital	10	0.08	10.59	0.1	6.4	4	40.00	0	0.00	1	10.00	3	30.00	1	10.00	1	10.00
Champawat	3	2.02		0.07	2.32	0	0.00	1	33.33	0	0.00	1	33.33	1	33.33	0	0.00
Pauri Garhwal	1	1.76		--		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	7	0.2	1.8	0.01	2.98	3	42.86	0	0.00	0	0.00	3	42.86	1	14.29	0	0.00
Total	**148**	**0.02**	**10.59**	**0.01**	**6.4**	**64**	43.24	**9**	6.08	**3**	2.03	**62**	41.89	**6**	4.05	**4**	2.70

5.4.2.3 Water Level Fluctuation (November 2016 versus November 2017)

The analysis of annual water level fluctuation data for 136 Ground Water Monitoring Wells in Uttarakhand is available. Analysis of the data has shown that the lowest annual rise is 0m at Garjia in Nainital district while the highest annual rise is 12.37 m at Majra in Dehradun district. During the post-monsoon period the lowest annual decline is 0.03 m at Badripur in Dehradun district while the highest annual decline is 5.32 m at Purukulgaon in Dehradun district.

A study of the water level fluctuation data has revealed that 85 monitoring wells out of 136 wells (62.5% of the total number) has recorded a rise in the range of 0-2 m. 5 monitoring well (3.68% of the total) had shown the higher rise of 2-4 m and 12 monitoring well (8.82 % of the total) had shown the highest rise of>4 m during this period. The 27 no of monitoring wells (19.85% of the total) had recorded an annual decline in the range of 0-2 m during the post monsoon period. 3 wells (2.21% of total number) had shown higher decline of water level in the range of 2-4 m whereas only 9 wells (2.94 % of total) had shown the highest annual decline of >4 m in water level.

The annual water level fluctuation map during the period November 2015 versus November 2016 is shown in ***Fig. 34*** *(Dehradun district), Fig.35 (Haridwar section)* and ***Fig. 36*** *(Nainital-Udham Singh Nagar-Champawat section)*.

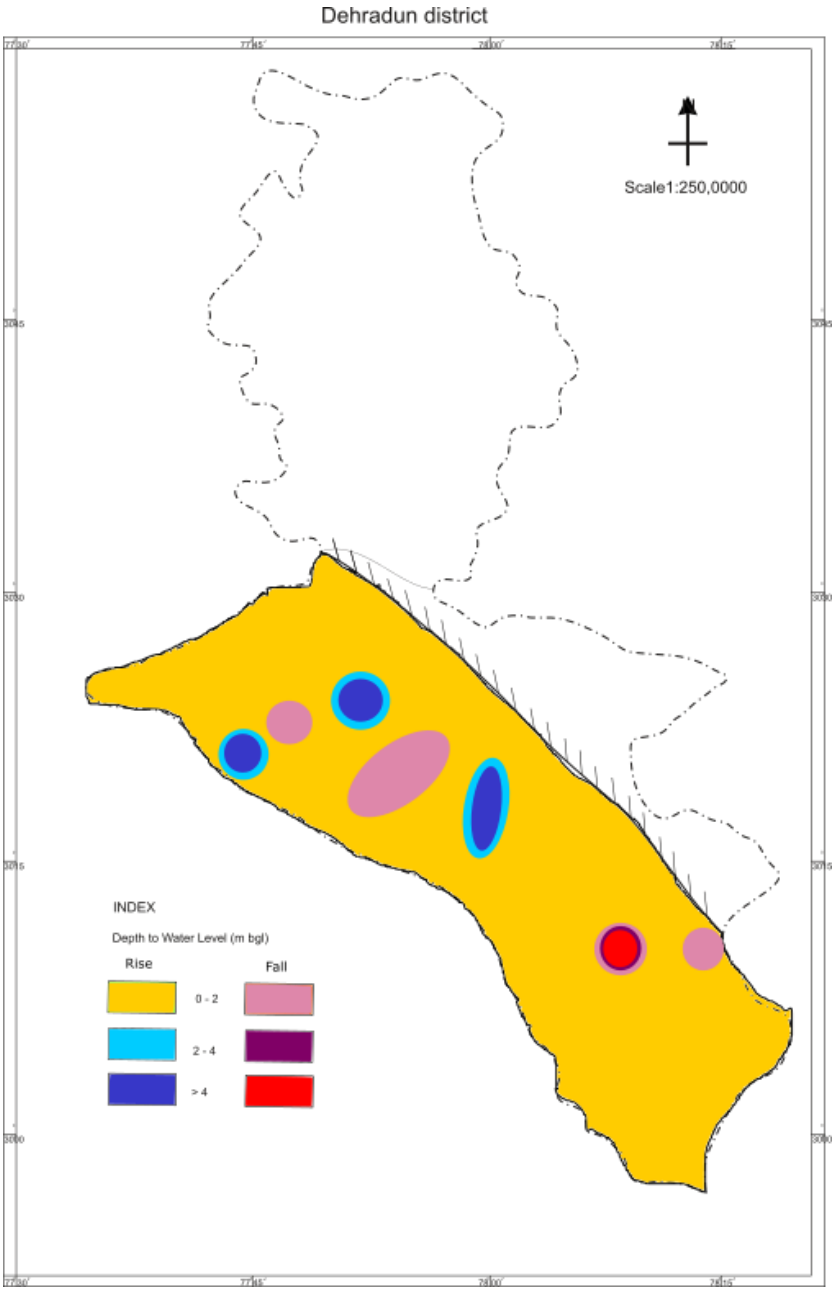


Figure 18 Annual Water Level Fluctuation Map (November 2015 vs 2016), Dehradun District

A perusal of Fig. 34 has shown that the minimum annual rise in post monsoon period in the range of 0-2 m is observed in more than 70% of the valley. Higher annual rise of 2-4 m is observed as zone encircling the >4m water level zone around Bhaniawala and Nanukhera. The minimum annual decline of 0-2 m is observed around Selaqui, Majra and Tarla Nagal. Higher annual decline of 2-4 m is observed as patches around Redarpur – Herbertpur; Kanwali and Lal Tappar. The highest annual decline of >4 m is observed around Harbanswala – Balliwala area in Doon valley during the post monsoon period.

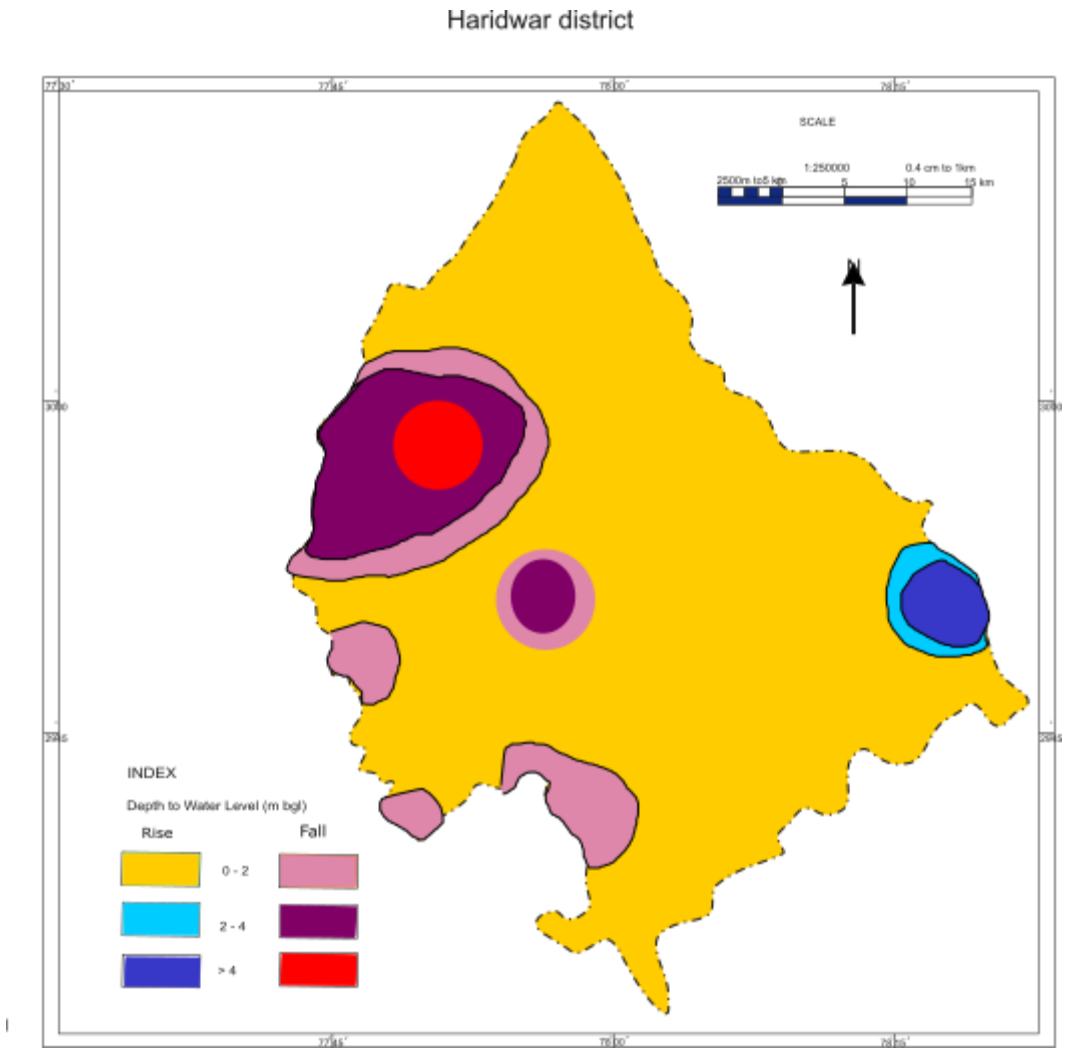


Figure 35 Annual Water Level Fluctuation Map (November 2015 vs 2016), Haridwar District

A perusal of **Fig. 35** has shown that the minimum annual rise in post monsoon period in the range of 0-2 m is major parts of the district; whereas the higher annual rise of 2-4 m is observed as isolated patch Bhagwanpur - Iqbalpur. The highest annual rise of >4 m is observed around Dhanpura in the Haridwar district. The minimum annual decline of 0-2 m is observed as isolated patch around Imlikhera and Rathura. Higher annual decline of 2-4 m is observed as inlier to the 0-2m water level zone around Lakhnauta. The highest annual decline of >4 m is observed around the Laldhang in Haridwar district during the post monsoon period.

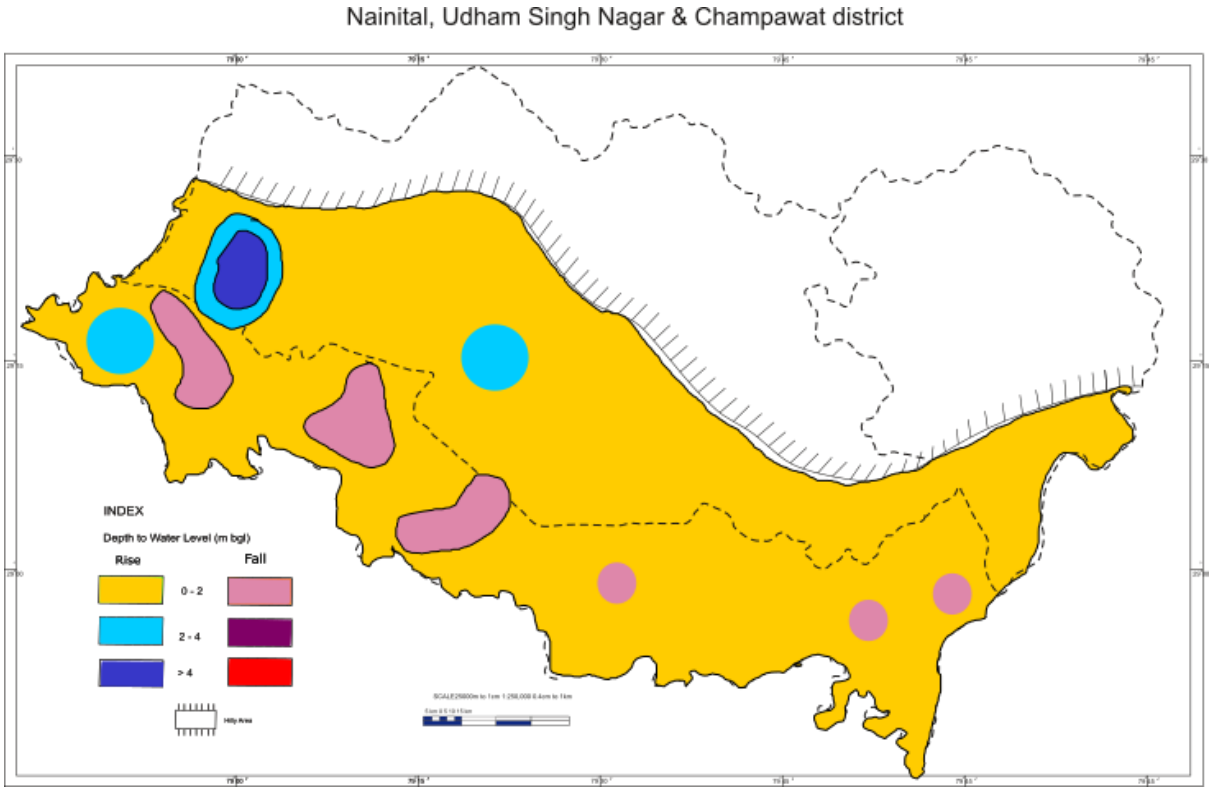


Figure 36 Annual Water Level Fluctuation Map (November 2015 vs 2016), US Nagar – Nainital - Champawat District

Interpretation of **Fig. 36** has shown that for the post monsoon period, the minimum annual rise of 0-2 m is observed in central and eastern part of the Tarai and Bhabar zone; and also as isolated patch around Kashipur – Patrampur in Udham Singh Nagar District. Higher annual rise of 2-4 m is observed as linear patch around Khatbass (Nainital District) and Chakarpur (Udham Singh Nagar District). The highest annual rise of >4 m is observed as inlier of the 2-4m water level rise zone around Dhoniya (Nainital district). The minimum annual decline of 0-2 m is observed around western part and southern parts of Tarai zone in Udham Singh Nagar district; also in northern part of Bhabhar Zone in Nanital district. Higher annual decline of 2-4 m is observed as the isolated patch around Sultanpur Patti (Udham Singh Nagar district); Peeru Madara and Kaladhungi in Nainital District. The highest annual decline of >4 m is observed around Dhela in Nainital district.

Table 18. Annual Water Level Fluctuation (November 2016 Versus November 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	44	0.04	12.37	0.03	5.32	25	56.82	2	4.54545	7	15.91	7	15.91	1	2.27	2	4.55
Haridwar	37	0.05	4.38	0.16	4.97	26	70.27	0	0.00	1	2.70	7	18.92	2	5.41	1	2.70
Udham Singh Nagar	36	0.01	2.01	0.03	1.13	23	63.89	1	2.78	0	0.00	12	33.33	0	26.00	0	0.00
Nainital	9	0	7.8	--		6	66.67	1	11.11	2	22.22	0	0.00	0	0.00	0	0.00
Champawat	2	0.51	1.21	--		2	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Pauri Garhwal	1	4.14		--		0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
Uttarkashi	7	0.39	6.39	0.06	7.93	3	42.86	1	14.29	1	14.29	1	14.29	0	0.00	1	14.29
Total	**136**	**0**	**12.37**	**0.03**	**5.32**	**85**	62.50	**5**	3.68	**12**	8.82	**27**	19.85	**3**	2.21	**4**	2.94

5.4.2.4 Water Level Fluctuation (January 2017 versus January 2018)

The analysis of water level data of 154 ground water monitoring wells for the period January 2017 versus January 2018 is given in ***Table 19.*** A perusal of the table indicates that the minimum annual rise is 0.005 m at Patthar Chatta in US Nagar district whereas the maximum annual rise is 12.04 m at Chiniyalisaur in Uttarkashi district. The minimum annual decline is found to be 0.02 m at Kashipur in US Nagar district whereas the maximum decline is 7.01 m at Dhela in Nanital district.

A perusal of the table also reveals that out of 154 monitoring wells, 66 wells (42.86%) have recorded the minimum annual rise in the range 0-2 m whereas 4 wells (2.6% of total wells) had shown higher rise in the range 2-4 m. 5no of monitoring wells (5 % of the total) had recorded the highest annual rise of >4 m during the period January 2016 to January 2017. Lowest annual decline of 0-2 m is recorded by 71 monitoring wells (46.1% of total) while 4 wells (2.6%) had recorded higher decline in the range of 2-4 m. The highest decline of >4 m is shown by 4 no of monitoring well (2.6% of total).

The annual water level fluctuation map during the period January 2017 versus January 2018 is shown in ***Fig. 37*** *(Dehradun district), Fig. 38 (Haridwar district)* and ***Fig. 39*** *(Nainital-Udham Singh Nagar-Champawat section)*.

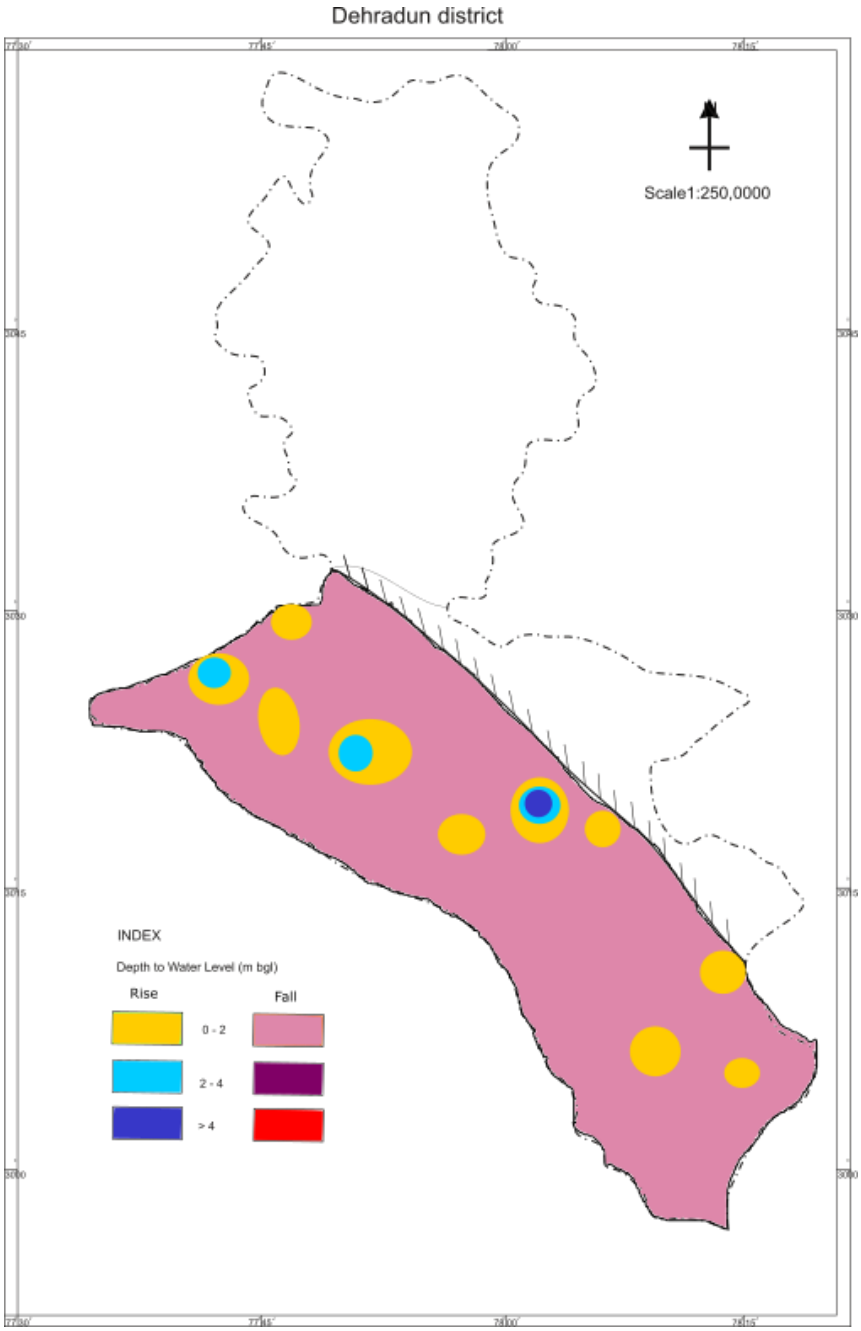


Figure 37 Annual Water Level Fluctuation Map (January 2016 vs 2017), Dehradun District

Visual interpretation of **Fig. 37** has shown that the minimum annual rise in the range of 0-2 m is observed as isolated patches around the Lal Tappar, Chhorba – Rampura. Higher annual rise of 2-4 m is observed at Singhniwala. Whereas the highest annual rise of >4 m is observed Majra. The minimal annual decline of 0-2 m is observed in the more than 70% of the valley. Higher annual decline of 2-4 m is observed as outlier to the >4m water level decline which is observed as isolated patch at Sabhawala.

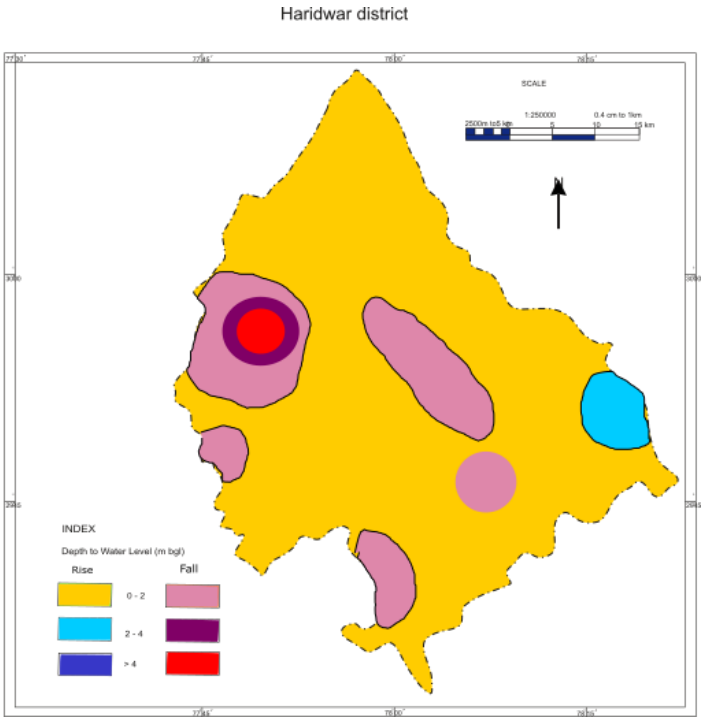


Figure 38 Annual Water Level Fluctuation Map (January 2016 vs 2017), Haridwar District

Visual interpretation of **Fig. 38** has shown that the minimum annual rise in the range of 0-2 m is observed in more than 75% of the district. Higher annual rise of 2-4 m is observed as isolated around Bhagwanpur and Bhikampur. The highest annual rise of >4 m is not observed in Haridwar district. The minimal annual decline of 0-2 m is observed as isolated patches around Imlikhera – Sahidwala Grant and Jhabrera – Lakhnauta – Gurkul Narsen and Dallawala. Higher annual decline of 2-4 m is observed as isolated patches around Laldhang in Haridwar district. The highest annual decline of >4 m is not recorded in any monitoring station in Haridwar district.

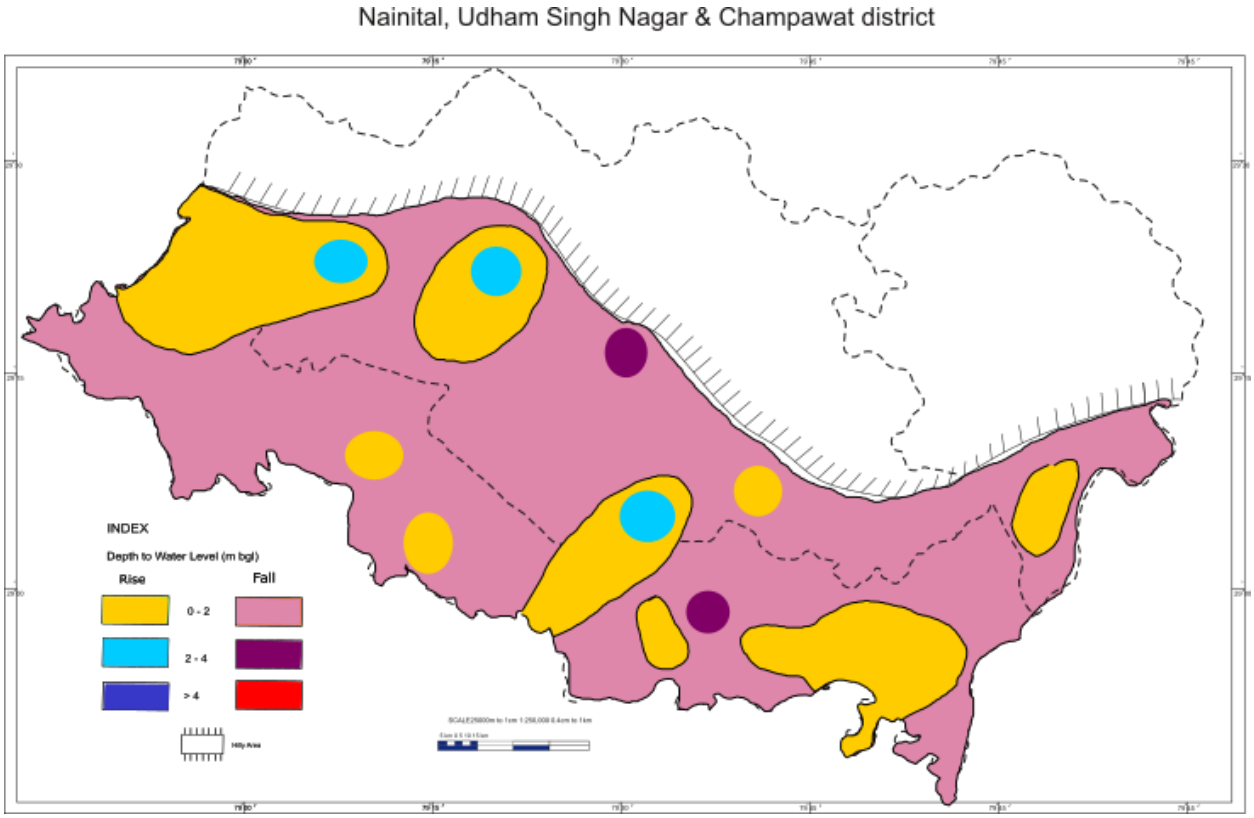


Figure 39 Annual Water Level Fluctuation Map (January 2017 vs 2018), US Nagar – Nainital - Champawat District

A perusal of **Fig. 39** indicates that the minimum annual rise of 0-2 m is observed in majority of the Bhabhar and Tarai zone. Higher annual rise of 2-4 m is observed as isolated patches around Bhagwanpur and Sultanpur Patti in Udham Singh Nagar District. The highest annual rise of >4 m is observed only around Kathgodham in Nainital district. The minimum annual decline of 0-2 m is observed around Patrampur, Bara, Bazpur, Sitarganj in Udham Singh Nagar District and Peeru Madara, Kaladhungi in Nainital District. The higher annual decline of 2-4 m is observed around Angadpur in Udham Singh Nagar District and the highest annual decline of >4 m is observed around Khatbass in Nainital District.

Table 19. Annual Water Level Fluctuation (January 2017 versus January 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0.03	7.46	0.01	5.30	17	35.42	3	6.25	1	2.08	25	52.08	1	2.08	1	2.08
Haridwar	39	0.02	2.19	0.02	4.38	26	66.67	1	2.56	0	0.00	11	28.21	0	0.00	1	2.56
Udham Singh Nagar	43	0.005	1.14	0.02	3.39	14	32.56	0	0.00	0	0.00	27	62.79	2	4.65	0	0.00
Nainital	13	0.19	3.07	0.25	7.01	4	30.77	0	0.00	3	23.08	4	30.77	1	7.69	1	7.69
Champawat	3	0.63	1.03	0.01		2	66.67	0	0.00	0	0.00	1	33.33	0	0.00	0	0.00
Pauri Garhwal	1	1.62		--		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	7	0.44	18.01	0.25	1.6	2	28.57	0	0.00	1	14.29	3	42.86	0	0.00	1	14.29
Total	**154**	**0.005**	**18.01**	**0.02**	**7.01**	**66**	42.86	**4**	2.60	**5**	3.25	**71**	46.10	**4**	2.60	**4**	2.60

5.4.3 SEASONAL WATER LEVEL FLUCTUATION

5.4.3.1 Water Level Fluctuation (May 2017 versus August 2017)

The seasonal fluctuation of water level during the period May 2017 versus August 2017 for 146 ground water monitoring wells in Uttarakhand State is given in ***Table 20.*** A perusal of the fluctuation data has shown that the minimum seasonal rise in ground water level was 0.01m at Shyampur in Haridwar district whereas the maximum rise was 18.2 m at Chilkiya in Nainital district. The minimum seasonal decline was 0.03 m at Nizampur in Haridwar district while the maximum decline was 11.95 m at Khaat Baans in Nanital district.

The perusal of Table 20 also reveals that rise in the range of 0-2 m was shown by 85 monitoring wells, which was 58.22% of the total number of wells. Higher rise in the range 2-4 m was shown by 31 wells (21.23% of total) while the highest rise of >4 m was shown by 10 wells (6.85% of total). The lowest seasonal decline of 0-2 m was recorded by 16 monitoring wells (10.96% of total). Higher seasonal decline of 2-4 m was shown by 1 monitoring wells, which was only 0.68% of the total number of wells during the period May versus August 2017. The highest seasonal decline of >4 m was recorded by 3 monitoring wells (2.05% of total).

The seasonal water level fluctuation map during the period May 2016 versus August 2016 is shown in ***Fig. 40*** *(Dehradun District),* ***Fig. 41*** *(Haridwar section)* and ***Fig. 42*** *(Nainital-Udham Singh Nagar-Champawat section)*.

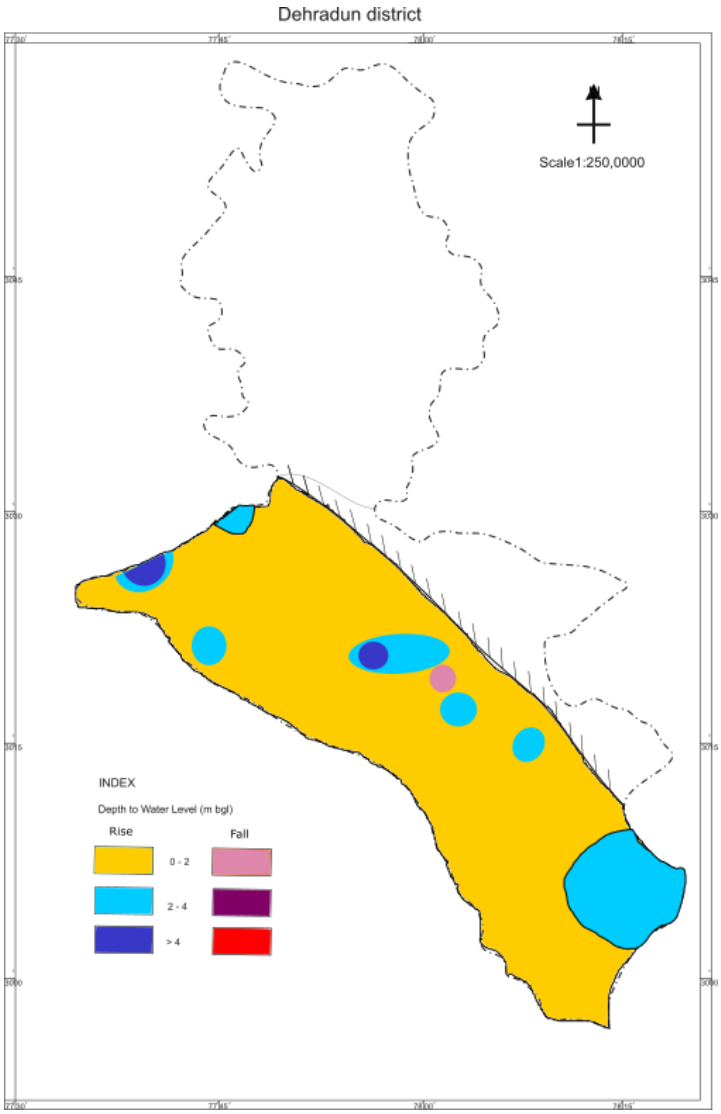


Figure 40 Water Level Fluctuation Map (May 2017 vs August 2017), Dehradun District

Visual interpretation of **Fig. 40** has shown that the lowest seasonal fluctuation of 0-2 m is observed in major parts of the Doon valley. The Seasonal rise of 2-4 m is observed as patches around Herbertpur – Judli and Shankarpur – Ramgarh – Balliwala area. The highest seasonal rise of water level (>4 m) is extensively found in Sabhaweala – Rampura – Jhajra – Harbanswala – section and also as isolated patch around Bhaniawala.

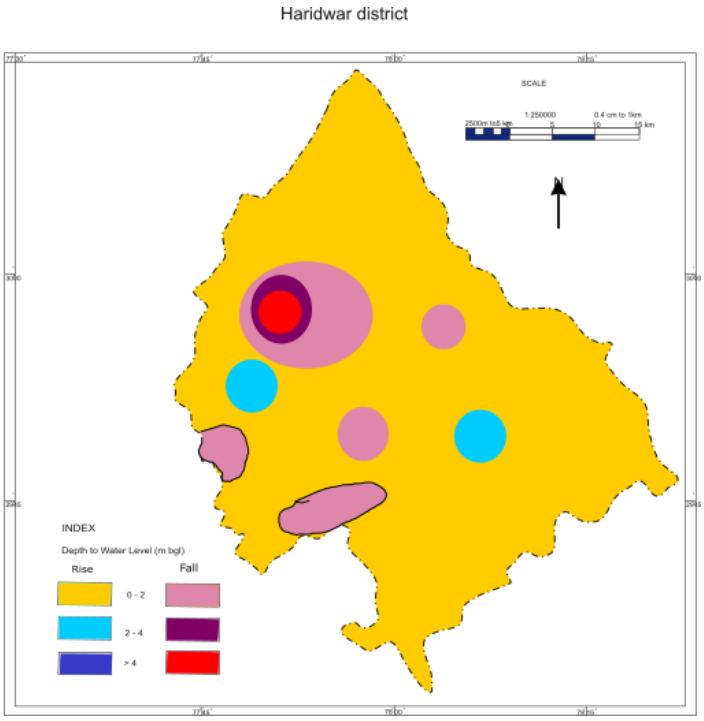


Figure 41 Water Level Fluctuation Map (May 2016 vs August 2016), Haridwar District

Visual interpretation of **Fig. 41** has shown that the lowest seasonal fluctuation of 0-2 m is observed dominantly in the eastern, south eastern and southern part of the district. The Seasonal rise of 2-4 m is observed as isolated patches. The lowest seasonal decline of 0-2 m is observed as dominantely in the northern and western part of the district. Higher seasonal decline of 2-4 m is observed as outlier to the >4m zone which is observed around the Bhagwanpur.

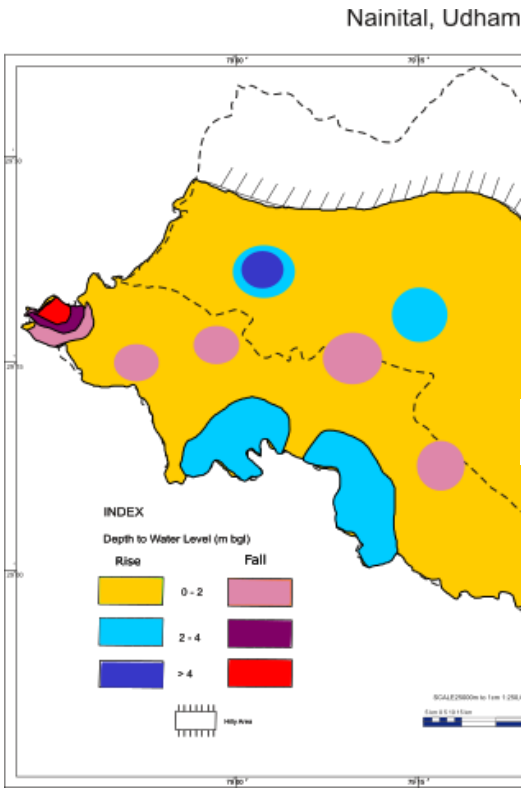


Figure 42 Water Level Fluctuation Map (May 2016 vs August 2016), US Nagar – Nainital - Champawat District

A perusal of **Fig. 42** indicates that the lowest positive seasonal fluctuation of 0-2 m is observed in the major parts of Tarai and Bhabar zone. Higher seasonal rise of 2-4 m is observed as patches. The highest seasonal rise of water level (>4 m) is observed in Champawat district. The lowest seasonal decline of 0-2 m is observed as isolated patches in Udham Singh Nagar district. Seasonal decline of 2-4m is observed as inlier to the seasonal decline zone of >4m. The highest seasonal decline of water level (>4 m) is observed as isolated patch in central Nainital district and wetern US Nagar.

Table 20. Seasonal Water Level Fluctuation (May 2017 Versus August 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0.035	6.85	0.17		27	56.25	15	31.25	5	10.42	1	2.08	0	0.00	0	0.00
Haridwar	38	0.01	2.49	0.07	5.8	28	73.68	2	5.26		0.00	7	18.42	0	0.00	1	2.63
Udham Singh Nagar	43	0.07	4.03	0.03	4.5	24	55.81	11	25.58	1	2.33	5	11.63	1	2.33	1	2.33
Nainital	6	1	18.2	11.95		1	16.67	2	33.33	2	33.33	0	0.00	0	0.00	1	16.67
Champawat	2	5.6	6.4	--		0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00
Pauri Garhwal	1	1.62		--		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	8	0.71	3.2	0.09	0.33	4	50.00	1	12.50	0	0.00	3	37.50	0	0.00	0	0.00
Total	**146**	**0.01**	**18.2**	**0.03**	**11.95**	**85**	58.22	**31**	21.23	**10**	6.85	**16**	10.96	**1**	0.68	**3**	2.05

5.4.3.2 Water Level Fluctuation (May 2017 versus November 2017)

The water level fluctuation data of May 2017 was compared with that of November 2017 for 148 ground water monitoring wells in Uttarakhand and the result is given in ***Table 21.*** Analysis of the fluctuation data for the period May-November (pre-monsoon versus post-monsoon) indicates that the minimum seasonal rise was 0.005 m at Kanwali in Dehradun district while the maximum was 10.98 m at Peerumadara in Nainital district. The annual decline was 0.02m at Shyampur in Haridwar district whereas the maximum decline was 10.65 m at Khaatbaans in Nanital district.

A perusal of the fluctuation data also shows that seasonal rise of 0-2 m was shown by 84 monitoring wells out of 121 (56.76%), that in the range of 2-4 m by 33 monitoring wells (22.3% of total) and that in the range of >4 m by 7 wells (4.73% of total) in Uttarakhand State. Seasonal decline in the range 0-2 m was recorded by 18 monitoring wells (12.16% of total). Higher seasonal decline in the range of 2-4 m had been recorded by 2 no of monitoring wells (1.35% of total) and the highest decline of >4 m was recorded by 04 (2.7%) monitoring well.

The seasonal water level fluctuation map during the period May 2017 versus November 2017 is shown in ***Fig. 43*** *(Dehradun district),* ***Fig.44*** *(Haridwar District)* and ***Fig. 45*** *(Nainital-Udham Singh Nagar-Champawat section)*.

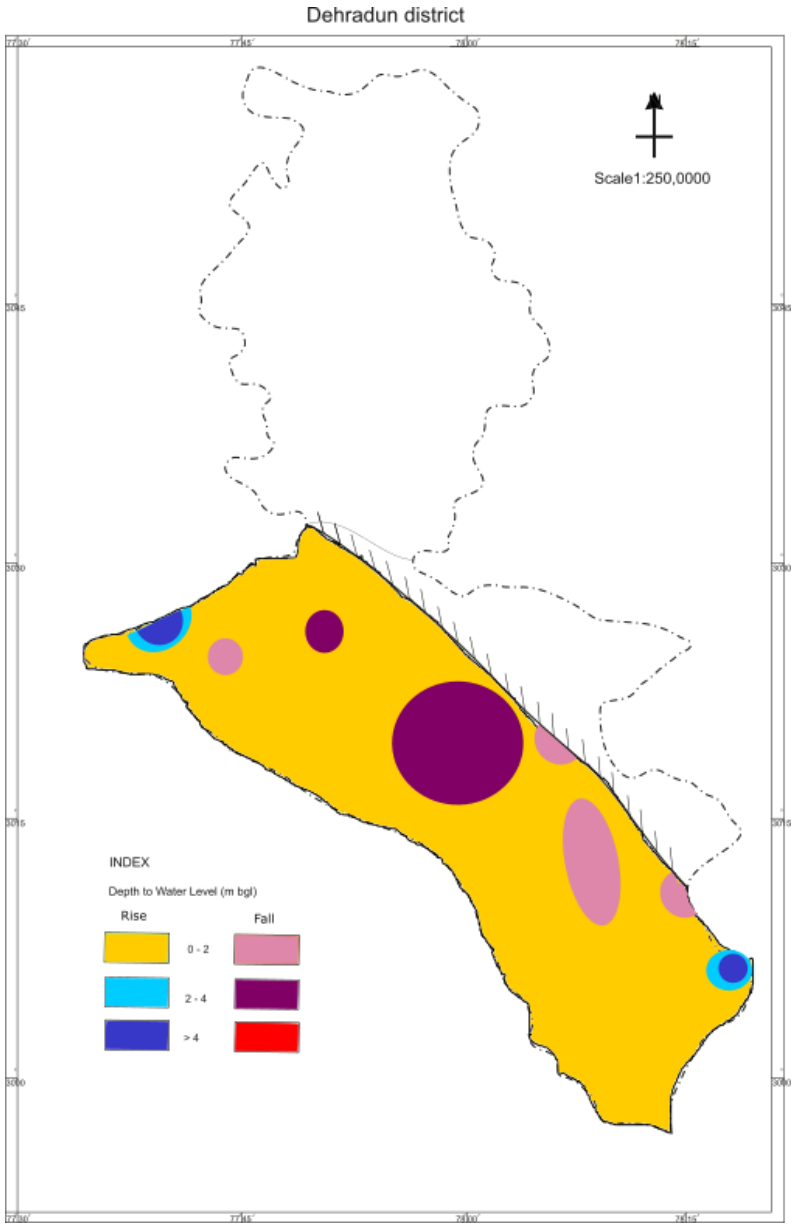


Figure 43 Water Level Fluctuation Map (May 2016 vs November 2016), Dehradun District

Visual interpretation of **Fig. 43** has revealed that the lowest seasonal rise of 0-2 m is observed in major parts of the Doon valley. Higher seasonal rise of 2-4 m is observed as outlier to the >4m seasonal rise zone. The highest seasonal rise of >4 m is observed around Dhakrani – Dharmawala – Barotiwala; Kuanwala - Bhaniawala and as isolated patch around Jhajra and Khandgaon. Seasonal decline in the range of 0-2m is observed as outliers to the Seasonal decline in the range of 2-4 m, which are around Majra, Dandhi and Vikasnagar. The seasonal decline in the range of >4 m is observed around Balliwala and Khandgaon.

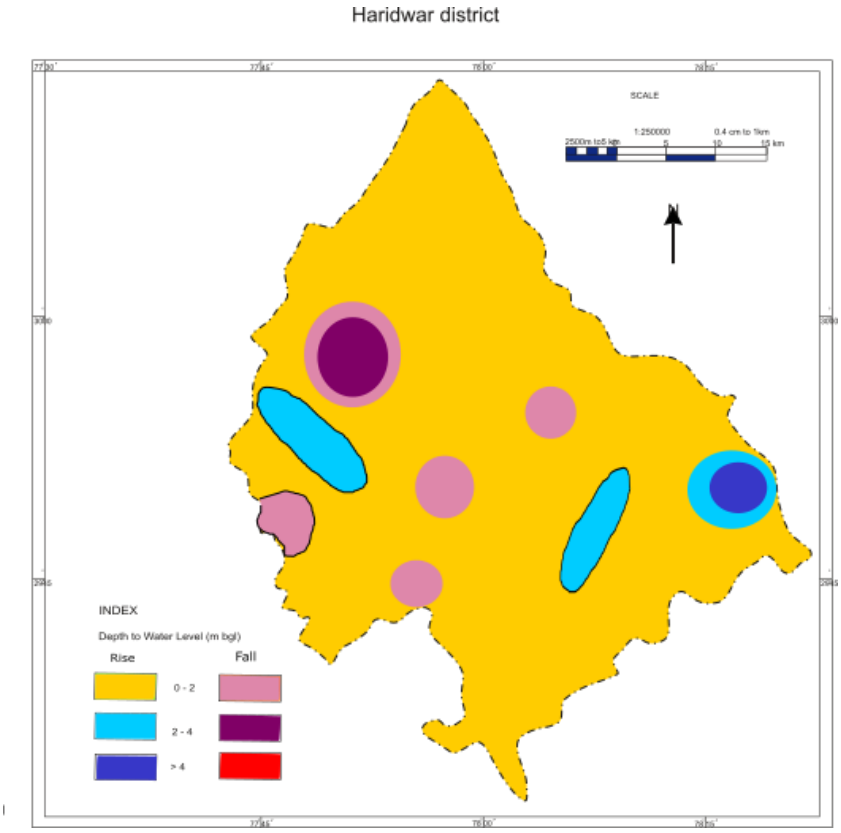


Figure 44 Water Level Fluctuation Map (May 2016 vs November 2016), Haridwar District

Visual interpretation of **Fig. 44** has revealed that the lowest seasonal rise of 0-2 m is observed dominantly in central, southern and southern eastern part. Higher seasonal rise of 2-4 m is observed as patches around Hussainpur Laldhang, sahidwala grant. The highest seasonal rise of >4 m is observed around Landhaura – Libraheri and Bhagwanpur in the district as per available data of the monitoring wells. The lowest seasonal decline of 0-2 m is observed in northern part of the district and as isolated patch around Bhogpur.

The seasonal decline in the range of 2-4 m is observed as isolated patch around Chudiala – Iqbalpur and Imlikhera - Bahadrabad and >4 m is not recorded in any of the monitoring stations in the district.

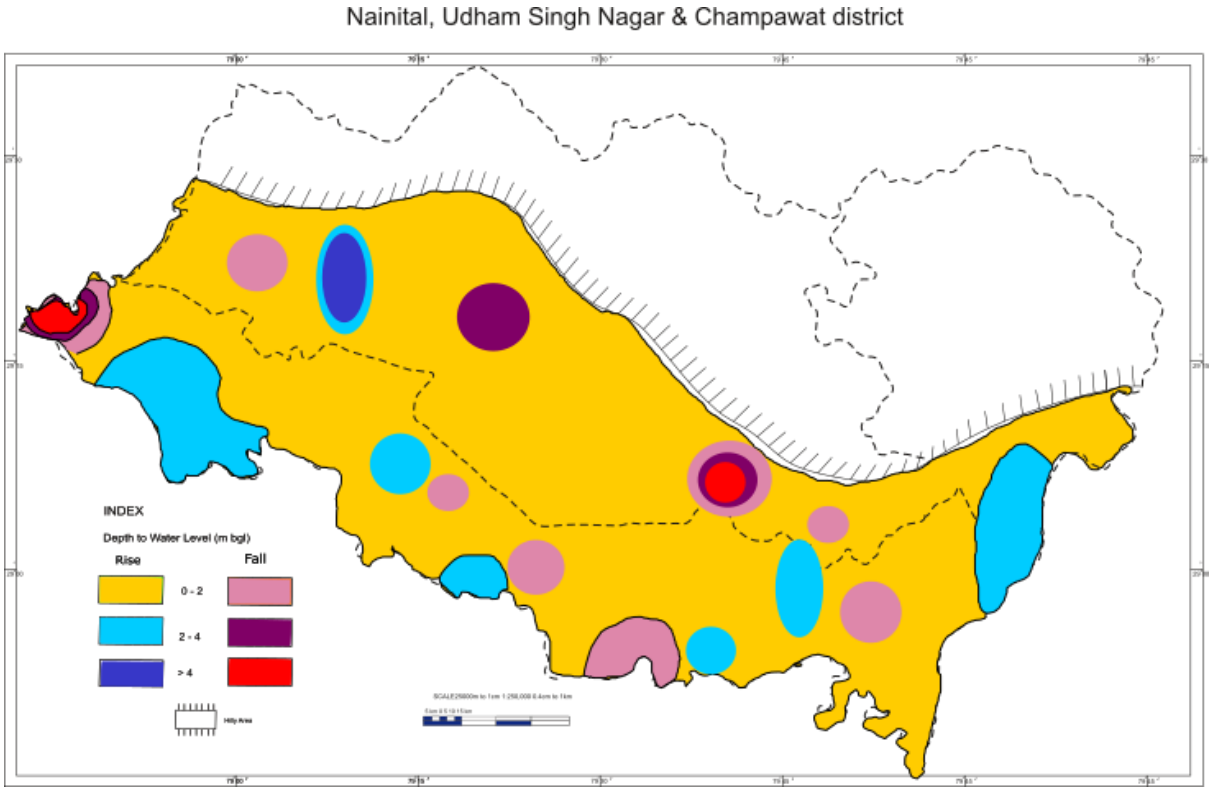


Figure 45 Water Level Fluctuation Map (May 2016 vs November 2016), US Nagar – Nainital - Champawat District

A perusal of **Fig. 45** has shown that the lowest positive seasonal fluctuation of 0-2 m is observed in major parts of Bhabhar and Tarai zone. Higher seasonal rise of 2-4 m is observed as patches around Jaspur – Durgapur - Missarwala - Sitarganj and Chakarpur in Udham Singh Nagar district and Kaladhungi – Kathgodham in Nainital district. The highest seasonal rise of water level (>4 m) is observed around Peeru Madara in Nainital district. The lowest seasonal decline of 0-2 m is observed as patches around Mahabir Nagar, Sarasariya, Kanakpur, Kalyanpur in Udhamsingh nagar district and as curvilinear patch in northern Bhabar zone. Seasonal decline of 2-4m is observed as outlier to the seasonal decline zone of >4m at Sultanpur Patti in Udham Singh nagar district and around Dhela – Ram Nagar – Dhoniya – Khat bass in Nainital district.

Table 21. Seasonal Water Level Fluctuation (May 2017 Versus November 2017)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	48	0.005	5.24	0.10	0.71	26	54.17	13	27.0833	4	8.33	5	10.42	0	0.00	0	0.00
Haridwar	39	0.11	5.07	0.02	3.4	26	66.67	5	12.82	1	2.56	6	15.38	1	2.56	0	0.00
Udham Singh Nagar	43	0.01	3.38	0.17	4.24	26	60.47	10	23.26	0	0.00	6	13.95	0	0.00	1	2.33
Nainital	7	0.55	10.98	10.65		2	28.57	2	28.57	2	28.57	0	0.00	0	0.00	1	14.29
Champawat	2	3.4	3.9	--		0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Pauri Garhwal	1	0.53		--		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	8	0.04	3.59	0.25	6.14	3	37.50	1	12.50	0	0.00	1	12.50	1	12.50	2	25.00
Total	**148**	**0.005**	**10.98**	**0.02**	**10.65**	**84**	56.76	**33**	22.30	**7**	4.73	**18**	12.16	**2**	1.35	**4**	2.70

5.4.3.3 Water Level Fluctuation (May 2017 Versus January 2018)

The seasonal water level fluctuation for the period May 2017 versus January 2018 is available for 142 monitoring wells in Uttarakhand State. The water level fluctuation data is given in ***Table 22.*** A perusal of the table indicates that the minimum rise was 0.005 m at Ganeshpur in Uttarkashi District while the maximum fluctuation was 10.1 m at Peeru Madara in Nainital district. The minimum seasonal decline in ground water level was 0.1 m at Gularghati in Dehradun District while the maximum decline was 12.39 m at Khaat Baans in Nanital District.

A perusal of **Table 22** also reveals that that the lowest seasonal rise of 0-2 m was shown by 92 monitoring wells (64.79% of total) whereas higher rise of 2-4 m was shown by 09 wells (6.34% of total). The highest seasonal rise of >4 m was shown by 7 wells, which was 4.93% of the total wells. Seasonal decline in the range of 0-2 m was shown by 26 monitoring wells (18.31% of total) while higher decline of 2-4 m was shown by 4 wells (2.82% of total). The highest decline of >4 m was recorded by 4 monitoring wells (2.82% of total) for which the data is available in Uttarakhand State during the period May 2017 versus January 2018.

The seasonal water level fluctuation map during the period May 2016 versus January 2017 is shown in ***Fig. 46*** *(Dehradun district),* ***Fig 47(****Haridwar district)* and ***Fig. 48*** *(Nainital-Udham Singh Nagar-Champawat section)*.

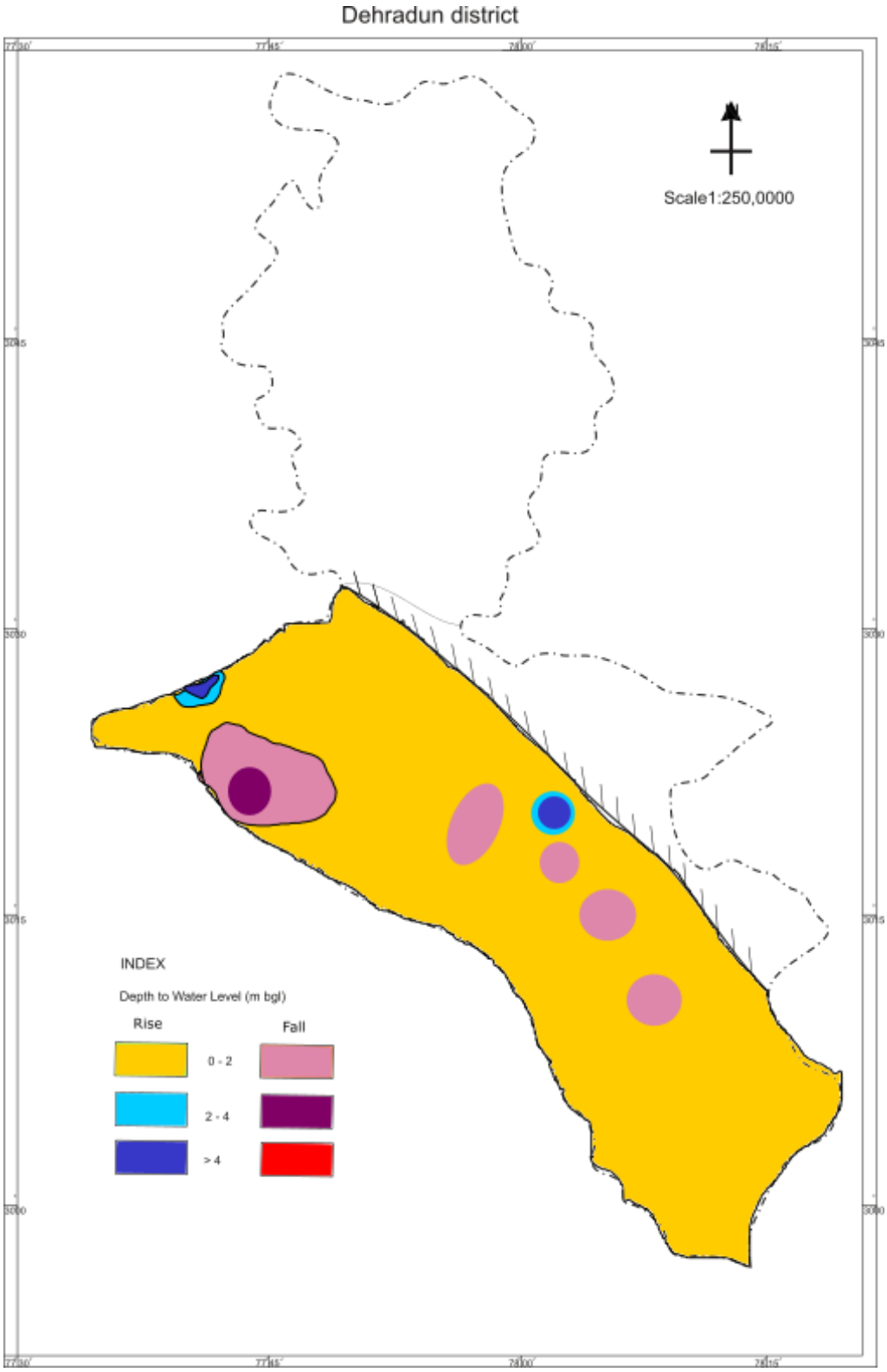


Figure 46 Water Level Fluctuation Map (May 2016 vs January 2017), Dehradun District

Interpretation of **Fig. 46** indicates that the minimum decadal rise of 0-2 m is observed in more than 50% area of the Doon valley. The seasonal rise of 2-4 m is observed as isolated patch in eastern part of the district. The lowest seasonal decline of 0-2 m is observed as circular isolated patches in central parthe doon valley. The seasonal decline in the range of 2-4 m is recorded as inlier of the 0-2m seasonal decline zone.

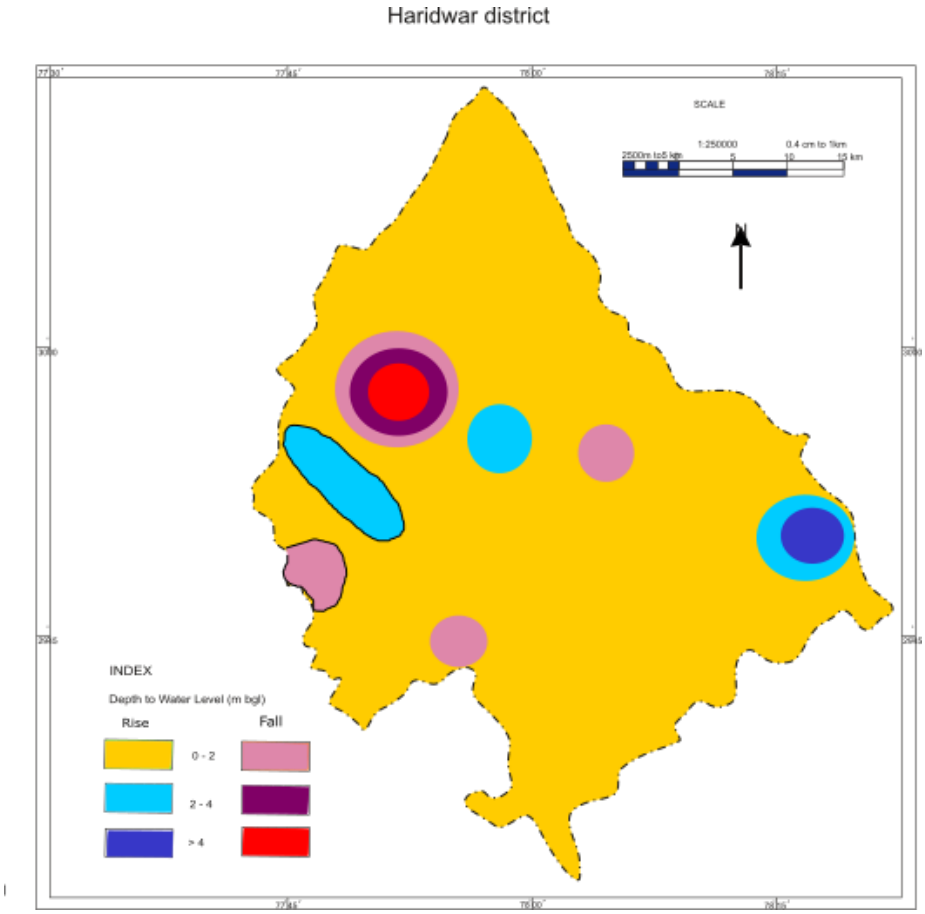


Figure 47 Water Level Fluctuation Map (May 2016 vs January 2017), Haridwar District

Visual interpretation of **Fig. 47** has revealed that the lowest seasonal rise of 0-2 m is observed dominantly in central, southern and western part. Higher seasonal rise of 2-4 m is observed ain eastern and western part. The highest seasonal rise of >4 m is observed around Laldhang in the district as per available data of the monitoring wells. The lowest seasonal decline of 0-2 m is observed in northern part of the district. The seasonal decline in the range of 2-4 m is observed as outlier to >4 m and is recorded in western part of district.

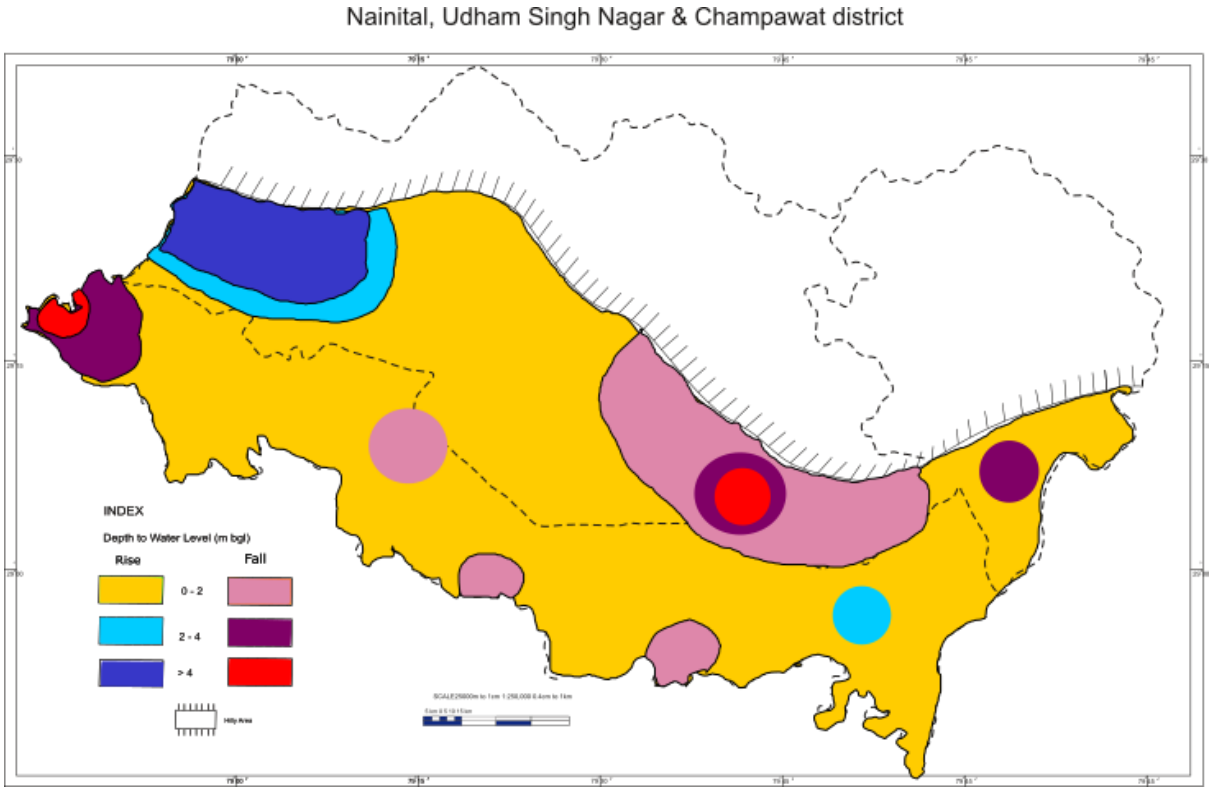


Figure 48 Water Level Fluctuation Map (May 2016 vs January 2017), US Nagar – Nainital - Champawat District

Visual interpretation of **Fig. 48** has shown that the minimum seasonal rise of 0-2 m is observed dominantly in northern, central and southern part of the Tarai zone and central and eastern part of Bhabar zone. Higher seasonal rise of 2-4 m is observed in western part of Nainital district as outlier to >4 m rise and as isolated patch in Udham Singh Nagar district. The minimum seasonal decline of 0-2 m is observed as outlier to the 2-4m seasonal decline zone and as isolated patches in Udham Singh Nagar district. Seasonal decline of 2-4m is observed as outlier to the seasonal decline zone of >4m, which is observed at western part (Udham Singh Nagar district), around Dhoniya, Khatbass (Nainital district).

Table 22. Seasonal Water Level Fluctuation (May 2017 versus January 2018)

District	No. of stations analyzed	Fluctuation (m)				Rise (m)						Decline (m)					
		Rise		Decline		0-2		2 to 4		>4		0-2		2 to 4		>4	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Dehradun	47	0	6.81	0.10	3.15	26	55.32	3	6.38298	2	4.26	14	29.79	2	4.26	0	0.00
Haridwar	38	0.08	5.19	0.32	4.39	29	76.32	3	7.89	1	2.63	4	10.53	0	0.00	1	2.63
Udham Singh Nagar	40	0.08	5.19	0.12	3.91	31	77.50	2	5.00	1	2.50	5	12.50	1	2.50	0	0.00
Nainital	7	0.3	10.1	0.35	12.39	2	28.57	0	0.00	3	42.86	1	14.29	0	0.00	1	14.29
Champawat	1	--		3.17		0	0.00	0	0.00	0	0.00		0.00	1	100.00		0.00
Pauri Garhwal	1	0.1		--		1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Uttarkashi	8	0.005	2.33	0.36	9.29	3	37.50	1	12.50	0	0.00	2	25.00	0	0.00	2	25.00
Total	**142**	**0.005**	**10.1**	**0.1**	**12.39**	**92**	64.79	**9**	6.34	**7**	4.93	**26**	18.31	**4**	2.82	**4**	2.82

CHAPTER – 6

HYDROCHEMISTRY

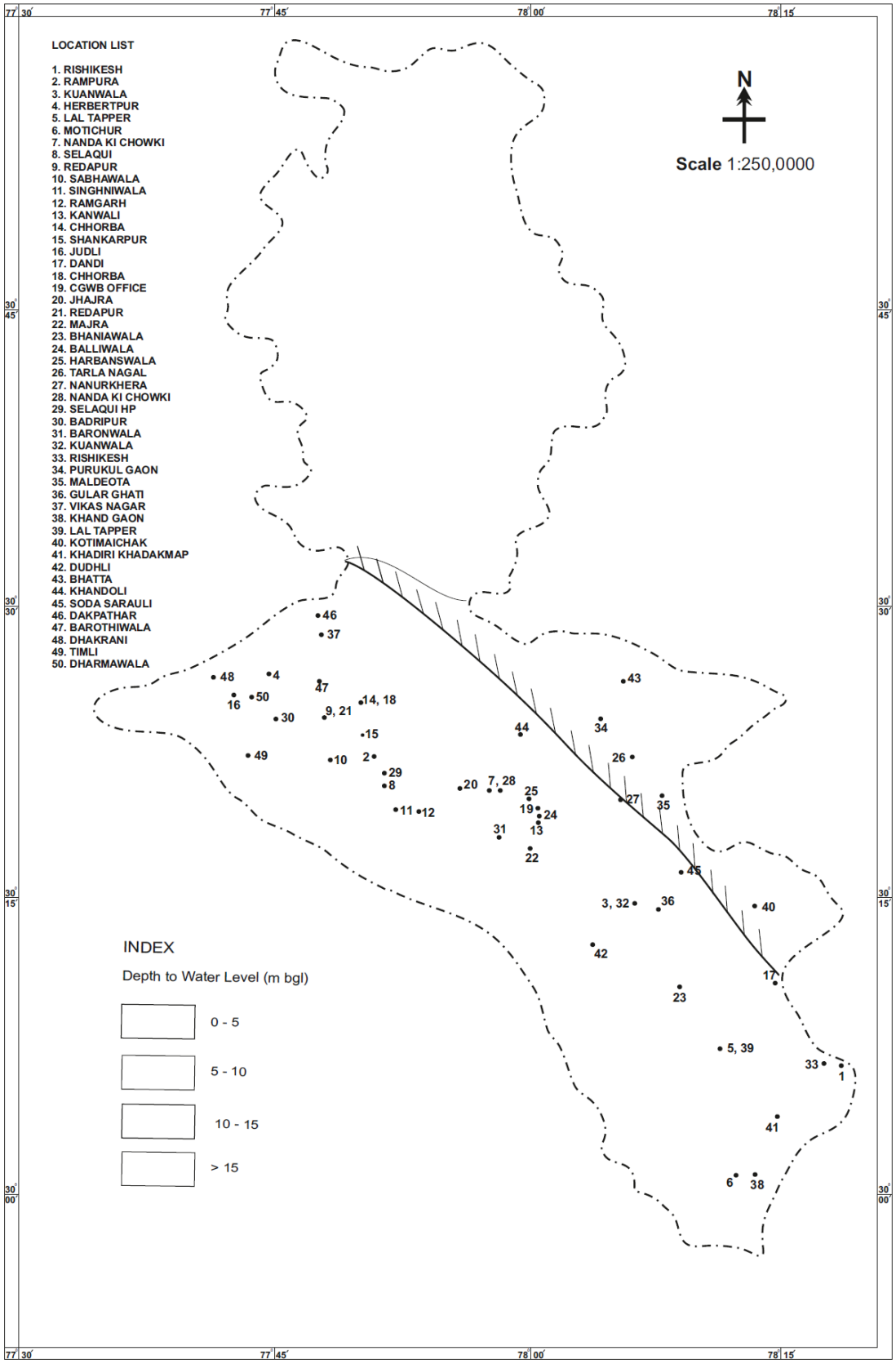
Monitoring of groundwater quality is very important as this determines the suitability of groundwater for various purposes like domestic, agricultural and industrial use and also for deciphering the water quality trends in space and time. Analysis of hydrochemical data also helps in evaluating the nature and extent of groundwater pollution and to ascertain the effectiveness of pollution control measures already in existence.

Four hundred and six (406) water samples collected during pre-monsoon period (May 2017) for Normal, Heavy and Arsenic analysis, were deposited at Chemical Laboratory, North Region, Luckhnow. The water samples were collected from ground water monitoring stations like dug wells, hand pumps and springs in Dehradun, Haridwar, Pauri Garhwal, Udham Singh Nagar, Nainital, Almora, Champawat and Uttarkashi districts.

The analysis results are awaited till the compilation of the report.

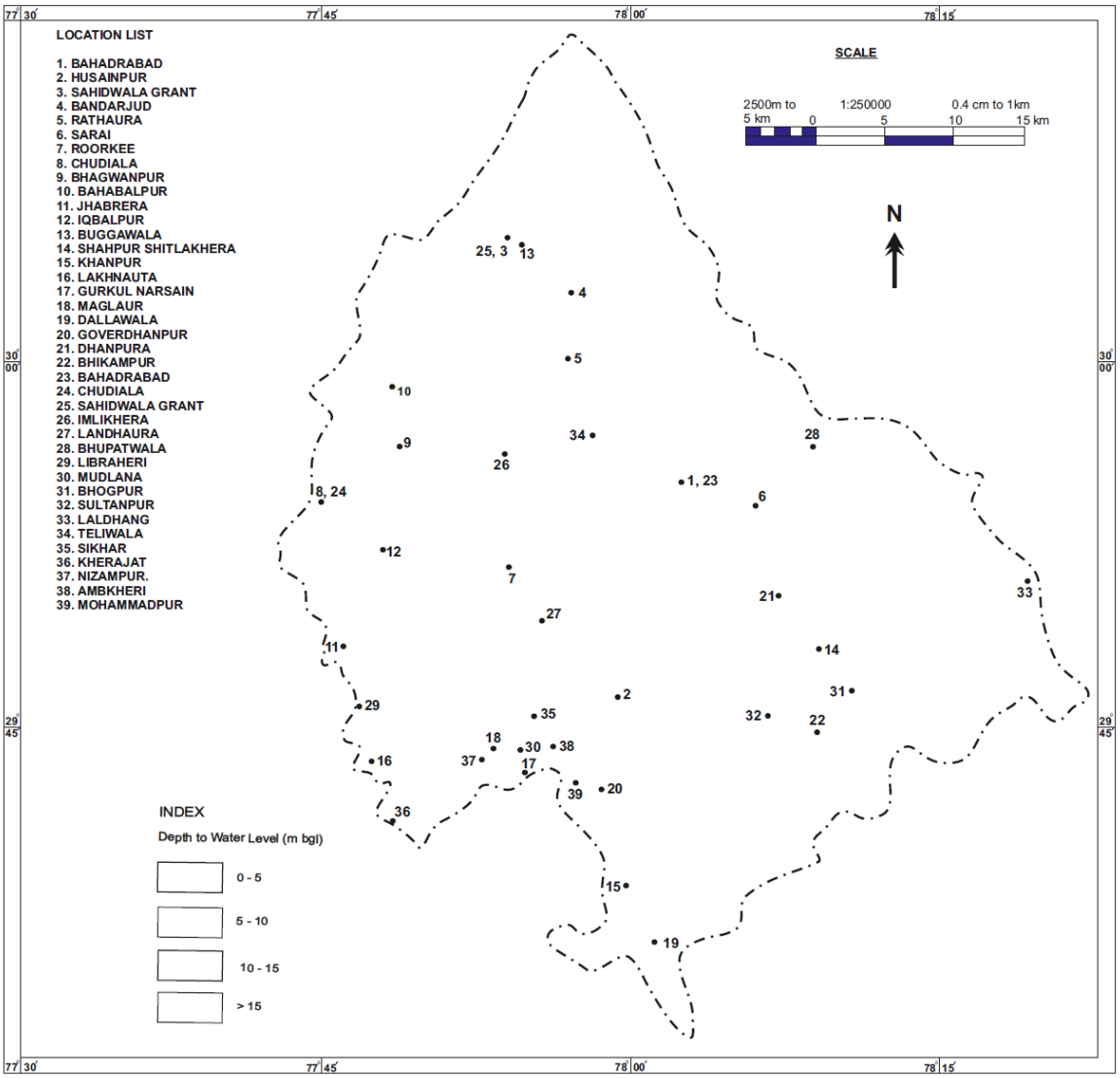
Annexure- I

Dehradun district



Annexure- II

Haridwar district



Annexure – III

Nainital, Udham Singh Nagar & Champawat district