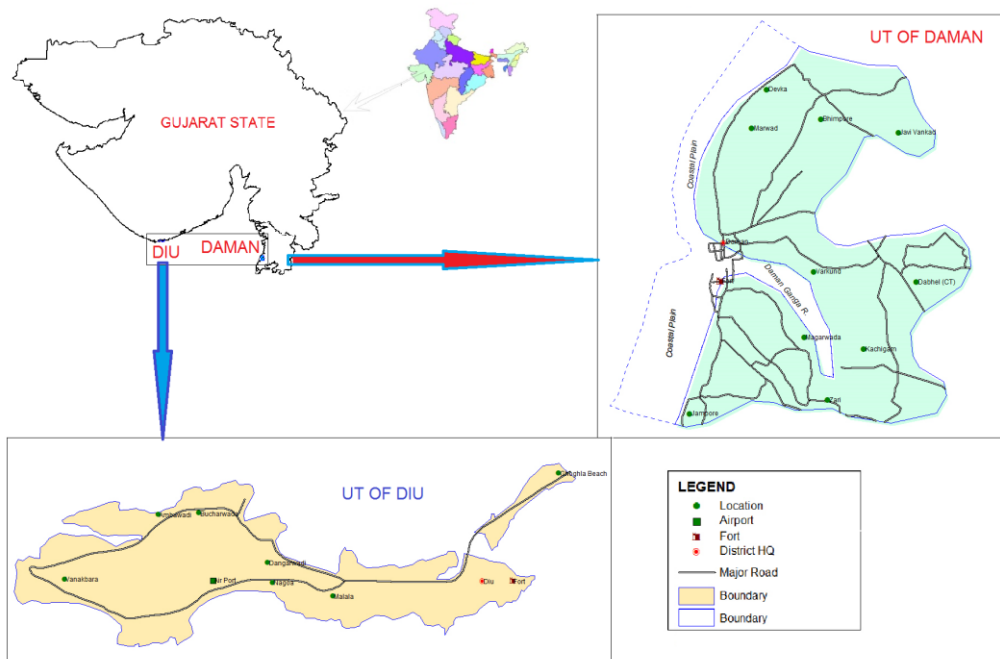




**CENTRAL GROUND WATER BOARD**  
**MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT**  
**AND GANGA REJUVENATION**

**GOVERNMENT OF INDIA**



**GROUNDWATER YEAR BOOK – 2018 - 19**

**UT OF DAMAN & DIU**

**REGIONAL OFFICE DATA CENTRE**  
**CENTRAL GROUND WATER BOARD**  
**WEST CENTRAL REGION**  
**AHMEDABAD**

May - 2020



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**GROUNDWATER YEAR BOOK – 2018 -19**  
**UT OF DAMAN & DIU**

Compiled by

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**REGIONAL OFFICE DATA CENTRE**  
**CENTRAL GROUND WATER BOARD**  
**WEST CENTRAL REGION**  
**AHMEDABAD**

May - 2020

## FOREWORD

*Central Ground Water Board, West Central Region, has been issuing Ground Water Year Book annually for UT of Daman and Diu in Gujarat state by compiling the hydrogeological, hydrochemical and groundwater level data collected from the Groundwater Monitoring Wells established by the Board in Gujarat State. Monitoring of groundwater level and chemical quality furnish valuable information on the ground water regime characteristics of the different hydrogeological units moreover, analysis of these valuable data collected from existing observation wells during May, August, November and January in each ground water year (June to May) indicate the pattern of ground water movement, changes in recharge-discharge relationship, behavior of water level and qualitative & quantitative changes of ground water regime in time and space. It also helps in identifying and delineating areas prone to decline of water table and piezometric surface due to large scale withdrawal of ground water for industrial, agricultural and urban water supply requirement. Further water logging prone areas can also be identified with historical water level data analysis. This year book contains the data and analysis of ground water regime monitoring for the year 2018-19.*

*The behavior of groundwater levels as analyzed from the existing Groundwater Monitoring Wells data and the chemical quality of groundwater is discussed in details in this report along with the thematic maps depicting the ground water scenario for different periods of measurements. The depth to water level, water level fluctuations, water table and water quality maps have been prepared and presented in this report along with detailed discussion on each map.*

*The scientific officers of the Regional office have systematically collected field data from the Groundwater Monitoring Network Wells four times during the viz., May, August, November and January and the analysis of same has been presented in this report along with changes in different seasons and long term changes in water level. The water samples were collected during May 2018 were analysed in the Regional Chemical Laboratory of West Central Region Ahmedabad to bring out chemical characteristic of groundwater. As a special drive to monitor presence of arsenic in ground water, the concentration of arsenic has been measured and produced in the report.*

*I hope the report would be externally useful to various agencies engaged in groundwater development and management for fruitful planning in time and space.*

(Sourabh Gupta)  
Regional Director (I/C)

## Contents

<i>FOREWORD</i> .....	I
<b>EXECUTIVE SUMMARY</b> .....	1
<b>1.0 INTRODUCTION</b> .....	2
<b>2.0 HYDROGEOLOGY</b> .....	6
<b>2.1 UT OF DAMAN</b> .....	6
<b>2.2 UT OF DIU</b> .....	7
<b>3.0 GROUND WATER SCENARIO</b> .....	8
<b>3.1 Depth to Water Level (Unconfined Aquifer)</b> .....	9
<b>3.1.1 Depth to Water Level May 2018</b> .....	9
<b>3.1.2 Depth to Water Level August 2018</b> .....	9
<b>3.1.3 Depth to Water Level November 2018</b> .....	12
<b>3.1.4 Depth to Water Level January 2019</b> .....	12
<b>3.2 Seasonal Water Level Fluctuation</b> .....	15
<b>3.2.1 May 2018 to August 2018</b> .....	15
<b>3.2.2 May 2018 to November 2018</b> .....	15
<b>3.2.3 May 2018 to January 2019</b> .....	17
<b>3.3 Annual Water Level Fluctuation</b> .....	17
<b>3.3.1 May 2017 to May 2018</b> .....	17
<b>3.3.2 August 2017 to August 2018</b> .....	18
<b>3.3.4 January 2018 to January 2019</b> .....	18
<b>3.4 Long Term Ground Water Scenario</b> .....	19
<b>3.4.1 Decadal Average Depth to Water Level</b> .....	19
<b>3.4.1.1 Pre-monsoon Water Levels (2009-18)</b> .....	19
<b>3.4.1.2 Post-monsoon Water Levels (2009-18)</b> .....	19
<b>3.4.1 Decadal Variations</b> .....	21
<b>3.4.2.1 Decadal average of May (2008-2017) to May 2018</b> .....	21
<b>3.4.2.2 Decadal average of August (2008 to 2017) to August 2018</b> .....	21
<b>3.4.2.3 Decadal average of November(2008-2017) to November 2018</b> .....	22
<b>3.4.2.4 Decadal average of January(2009-2018) to January 2019</b> .....	22
<b>3.5 Water Table Scenario in May 2018</b> .....	24
<b>4. HYDROCHEMISTRY</b> .....	24
<b>4.1 Groundwater Quality Monitoring</b> .....	24
<b>4.2 Ground water quality scenario in the state</b> .....	25
<b>4.2.1 The Electrical conductivity</b> .....	25
<b>4.2.2 Chloride</b> .....	27
<b>4.2.3 Nitrate</b> .....	27
<b>4.2.4 Fluoride</b> .....	31
<b>4.2.5 Heavy Metal Analysis</b> .....	31
<b>Iron</b> .....	31
<b>Chromium</b> .....	31
<b>Copper</b> .....	31
<b>Manganese</b> .....	32
<b>Zinc</b> .....	32

## List of Annexures

Annexure I	Water levels of the National Hydrograph Stations in Gujarat state, 2018-19 (Phreatic)
Annexure II	Groundwater Table of Gujarat state during May 2018 (Phreatic)
Annexure III	Mean Decadal water levels of the National Hydrograph Stations in Gujarat state (Phreatic) 2009-18
Annexure IV	Water Quality Data of National Hydrograph Monitoring Stations of Gujarat state, May 2018
Annexure V	Heavy Metal Water Quality Data of National Hydrograph Monitoring Stations of Gujarat state, May 2018

## List of Tables

Table 01	District wise Average Annual Rainfall in UT of Daman and Diu
Table 02	Distribution of Groundwater monitoring wells in Different Hydrogeological Units
Table 03	Distribution of Groundwater monitoring wells in major river basin
Table 04	Distribution of GW monitoring well during 2018-19
Table 05	Wellwise categorisation of Depth to water level_May 2018
Table 06	Wellwise categorisation of Depth to water level_August 2018
Table 07	Wellwise categorisation of Depth to water level_November 2018
Table 08	Wellwise categorisation of Depth to water level_January 2019
Table 09	Categorisation of changes in water level between May 2018 to August 2018
Table 10	Categorisation of changes in water level between May 2018 to November 2018
Table 11	Categorisation of changes in water level between May 2018 to January 2019
Table 12	Categorisation of changes in water level between May 2017 to May 2018
Table 13	Categorisation of changes in water level between August 2017 to August 2018
Table 14	Categorisation of changes in water level between November 2017 to November 2018
Table 15	Categorisation of changes in water level between January 2018 to January 2019
Table 16	Well wise categorisation of changes in water level during May 2018 to decadal average of May 2008-17
Table 17	Well wise categorisation of changes in water level during August 2018 to decadal average of August 2008-17
Table 18	Well wise categorisation of changes in water level during November 2018 to decadal average of November 2008-17
Table 19	Well wise categorisation of changes in water level during January 2019 to decadal average of January 2009-18

## List of Figures

Figure 01	Map showing administrative divisions of UT in Gujarat state
Figure 02	UT of Daman_Major Geological map
Figure 03	UT of Diu_Major Geological map
Figure 04	Depth to water level map of May 2018
Figure 05	Depth to water level map of August 2018
Figure 06	Depth to water level map of November 2018
Figure 07	Depth to water level map of January 2019
Figure 08	Map showing seasonal fluctuation of water level May 2018 to November 2018
Figure 09	Map showing decadal average depth of water level during post-monsoon (2009-18)
Figure 10	Groundwater table contours of UT of Daman and Diu May 2018
Figure 11	Isocontor map of EC (May 2018)
Figure 12	Isocontor map of Chloride (May 2018)
Figure 13	Map of Nitrate concentration (May 2018)
Figure 14	Map of Flouride concentration (May 2018)
Figure 15	Map of Iron concentration (May 2018)

# **GROUNDWATER YEAR BOOK (2018-19)**

## **UT OF DAMAN & DIU**

### **EXECUTIVE SUMMARY**

- ◆ Central Ground Water Board has set up a network of 16 Groundwater Monitoring Wells including 5 piezometers. Initially the monitoring commenced with the establishment of 2 observation wells spread uniformly over the entire state, in the year 1969 and since then number of stations were added regularly so as to get proper hydrological information of different hydrogeological and geomorphological units.
- ◆ The density of groundwater monitoring wells is 7 sq km per well in UT of Daman & Diu.
- ◆ The average decadal rainfall varies from about 919.3 mm in Diu to about 2015.1 mm in Daman.
- ◆ The average rainfall for 2018 is 1601 mm, which is 20 percent more than the decadal average.
- ◆ Groundwater levels are being monitored four times in a year, and representative water samples for quality (inorganic constituents) are collected during pre-monsoon (May) period.
- ◆ 80% of the wells have depth to water levels in the range of 5 to 20 mbgl (meter below ground level) during pre-monsoon 2018. The rest water levels were shallow.
- ◆ As per GWRE 2017, UT of Daman is categorised as safe (51.25%) and UT of Diu is categorised as Critical (91.13%).
- ◆ The long term ground water scenario in comparison to pre monsoon 2018 indicates that 60% well shows fall where as in post monsoon rising trend is observed in 100% of wells.
- ◆ In general ground water quality is good in UT of Daman where as it is saline brackish in UT of Diu.
- ◆ The deterioration in ground water quality in the coastal areas is mainly due to over drawals causing seawater ingress which needs to be arrested.
- ◆ Pointed attention of the administrators and policy makers is drawn towards adoption of artificial recharge, public awareness and other appropriate measures for ensuring adequate groundwater availability and sustainability.

# GROUNDWATER YEAR BOOK, 2018-19, UT OF DAMAN & DIU

## 1.0 INTRODUCTION

The West Central Region of Central Ground Water Board has jurisdiction over the Union Territory (UT) of Daman & Diu covering an area of 112 sq km. Diu is an Island just south of Saurashtra coast and Daman is situated west of Vapi in the south. (Fig 01)

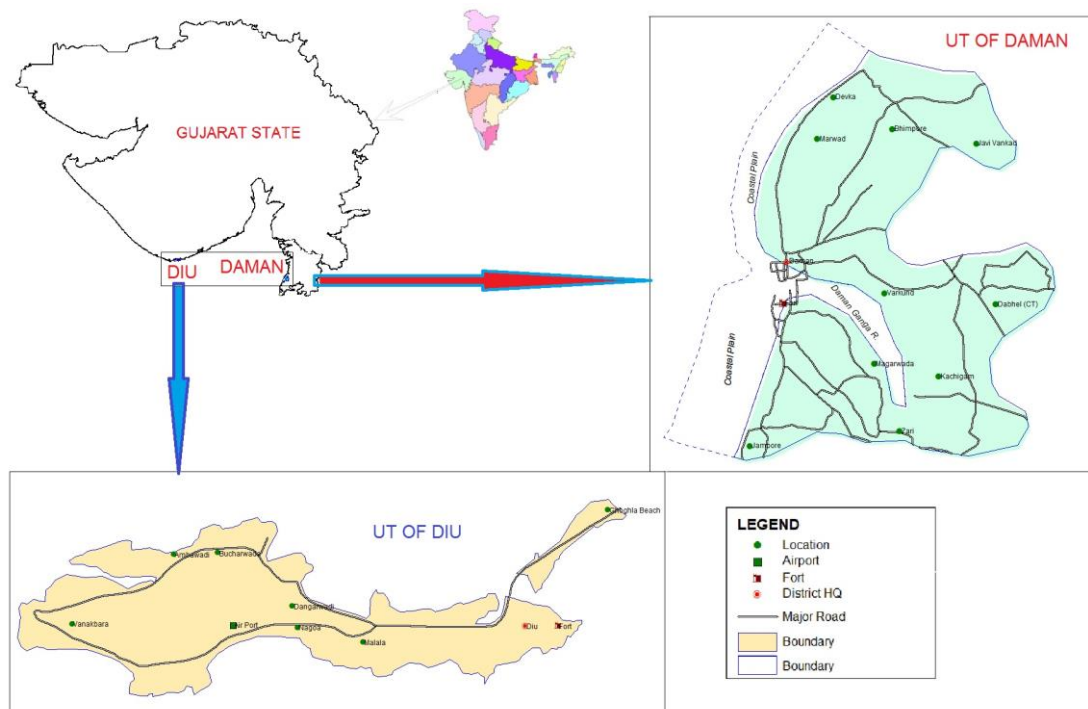
Daman is a small port on the Arabian Sea. Daman is situated between north latitudes 20°22' & 20°29'58" and east longitudes 72°49'42" & 72°54'43" and falls in Survey of India toposheet No. 46 D/15. It covers an area of 72 sq. km. Its length measures 11 km from extreme north to south and the width measures 8 km. from east to west. The UT is bounded on the north, east and south by Valsad district of Gujarat state and west by Arabian Sea.

The river Daman Ganga passing through the middle of Daman divided it in to two parts namely Moti Daman and Nani Daman. The altitude is 12 m amsl. The Kolak river flows along the northern boundary and the Kalu nadi forms the southern boundary. These three rivers flowing almost parallel to each other enter Daman from south east and follow almost westerly course. There are 22 villages, 10 village panchayats, one municipal council and one town under the Daman district.

The total population of the district as per 2001 census is 1,13,989, which includes 71634 male and 42355 female. The sex ratio is about 591 female per 1000 male. The rural population is 78219 and urban population is 35770.

Map showing administrative divisions of UT in Gujarat State

Fig 01



The mean minimum temperature is 12°C and the mean maximum temperature is 37°C. Due to proximity of the sea the humidity is generally high being 100% in the monsoon period and around 24% during summer. The winds are generally moderate except during late summer and monsoon period when they are very strong. The maximum wind speed is 30 km/hr.

Diu district of Union Territory of Daman & Diu is situated in southern part of Saurashtra region of Gujarat State, in western India. The Diu district is situated between north latitudes 20°44'39" & 20°42'00" and east longitudes 70°52'26" & 71°00'24" and falls in Survey of India toposheet No. 41 L/14. Its east west extent is nearly 19.2 km and north south width is varying from 1 to 2.5 km. Out of the total area of 43.8 Sq Km, 26.84 Sq. Km is rural area and 17.76 Sq.km is urban area.

The major part of Diu district has a distinct geomorphic identity as an *island*, is surrounded by the Arabian Sea while small portion, known as Gogala area, in northeast, is attached with mainland of Gujarat State. The Diu Island faces open sea in south and in north it is separated from mainland Gujarat by an east-west extending marshy low land and tidal waters of the Arabian Sea, known as *Sesalkhada Channel*. Topography of the Island is highly variable rolling nature but within range highest 30 m in central part to near sea level in northern part. Towards south east coast it is high cliff of 8 to 10 m facing open sea front except smooth beach of Nagua and Vanakwar. Large tract in between mainland Gujarat and Diu Island is covered by marshy and saline mud flats which are inundated by the diurnal tides daily.

Hydrogeological point of view, the UT of Diu has very limited natural water resources; as such its main area is an island surrounded by saline waterfronts on all sides, with no freshwater resources in form of rivers or streams except annual average rainfall of 750 mm during four months of south west monsoon cycle of Indian Subcontinent. It has excellent aquifer in form of typical Miolitic Limestone but it has limited thickness of 20 to 40 m as cap rocks, followed by poor aquifer of Gaj formations at depth. This natural constraint of limited ground water resources has become more acute by steadily increasing groundwater draft for ever increasing population and also due to rapid urbanisation and related activities in last two decades. In past, (during 1990-1998) at many places of the Diu Island and Gogala area deterioration of ground water quality has been reported due to sea water ingress in aquifer of the region and incidence of upconing of saline groundwater. Taking note of all such adverse effects of the development, in October 1998 the Central Ground Water Authority (CGWA) has notified whole of the Union Territory of Diu as a '*Critical Area*' and imposed prohibition and restriction on the construction, installation of any structures for extraction of groundwater resources to avoid its further depletion. It also authorised the Collector and Administrator of UT of Diu to take action as deem fit for prohibition and restriction on the construction, installation of any ground water abstraction structures in the notified area. It also directed to get registered all persons / agencies having ground water abstraction structures in existence and banned to undertake any scheme / project of groundwater development & management in the notified areas without permission of the Authority.

The total population of U.T. of Daman & Diu is 243,247 of which 150,301 are males and 92,976 are females (2011 Census).



The diverse physiographic, climatic, topographic and geologic conditions have given rise to diversified ground water situations in different parts of the UT. Occurrence and movement of groundwater is controlled by rock formations of varied composition and structure and range in age from Mesozoic to Recent. Similarly, the landform varies from the hilly tract to the uplands of Daman, the alluvial plains and miliolitic limestones in the low lying coastal tract. The topography and rainfall virtually control the runoff and ground water recharge.

During 2018, UT received 20% more rainfall than the average rainfall (Table 1) as compared to decadal average annual rainfall (2007-2016).

**Table - 1**

**District wise Average Annual Rainfall in UT of Daman & Diu**

Sl.No	District	Rainfall 2018	Average Rainfall in mm (2008 to 2017)	Departure % (Year 2018)
1	UT of Daman	1834.3	2015.1	-9.0
2	UT of Diu	1368.2	919.3	48.8
<b>UT of Daman &amp; Diu</b>		<b>1601</b>	<b>1467</b>	<b>20</b>

Two distinct hydro-geological units are identified in UT viz., hard rocks and soft rocks. The distributions of monitoring wells in different hydro-geological units are given in **Table 3**.

**Table - 2**

DISTRIBUTION OF GROUND WATER MONITORING WELLS IN DIFFERENT HYDROGEOLOGICAL UNITS, UT OF DAMAN AND DIU								
S.No	DISTRICT	Hard Rock		Soft Rock		Total		
		DW	PZ	DW	PZ	DW	PZ	Total
1	U.T.of Daman	8	1	0	0	8	1	9
2	U.T. of Diu	0	0	3	4	3	4	7
U.T. Total		8	1	3	4	11	5	16

River basins have been identified by the All India Soil Survey & Land Use Department as listed below:

1. Southern Kathiawar
2. Sharavati to Tapti

**Table 3**

**DISTRIBUTION OF GROUND WATER MONITORING WELLS IN THE MAJOR RIVER BASIN**

DISTRICT_NAME	BASIN_NAME	SUB_BASIN_NAME	Total
DAMAN	Sharavati to Tapti	Savitri To Tapti	8
		Sharavati To Savitri	1
	Sharavati to Tapti Total		9
DAMAN Total			9
DIU	Southern Kathiawar	Draining Into Gulf Of Khambat	7
	Southern Kathiawar Total		7
DIU Total			7
Grand Total			16

DISTRICT WISE DISTRIBUTION OF OF GROUND WATER MONITORING WELLS MONITORED DURING 2018-19																			
Sl. No.	District	As on rest of the field season 2018-19			NHS Well As on March 2019			Monitored During MAY- 2018			Monitored During AUGUST- 2018			Monitored During November - 2018			Monitored During January - 2019		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
UT OF DAMAN AND DIU																			
1	U.T.of Daman	8	1	9	8	1	9	6	0	6	8	0	8	8	0	8	7	0	7
2	U.T. of Diu	3	4	7	3	2	5	5	2	7	5	2	7	2	2	4	3	2	5
UT Total		11	5	16	11	3	14	11	2	13	13	2	15	10	2	12	10	2	12

The sub basins and the distribution of ground water monitoring wells in these different river basins are given in Table 3. Map showing Hydrograph stations monitored during the year and their distribution in different basin and the district.

Central Ground Water Board, as a part of its national programme, has established a network of observation wells in the U.T. of Daman and Diu for periodic monitoring of groundwater levels and to study its quality variation in time and space. 12 groundwater monitoring wells including 4 piezometers (Pz) are presently being monitored in the U.T. of Daman and Diu. The distributions of monitoring wells in different districts are given in **Table 3**.

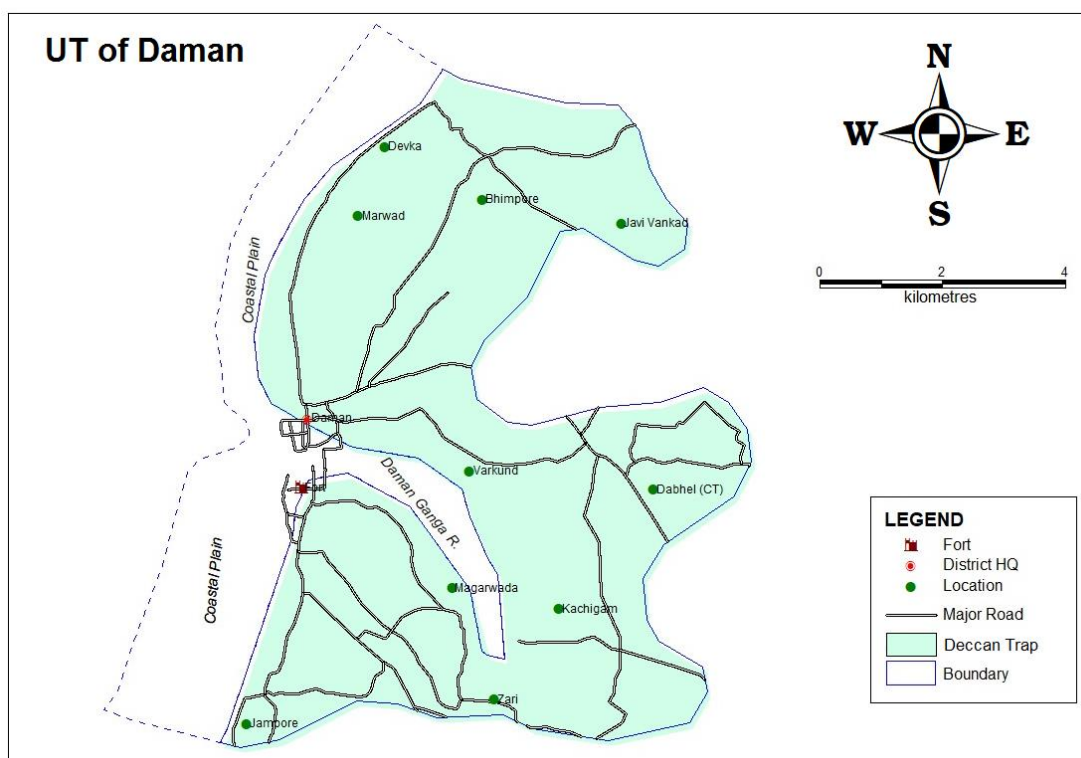
## 2.0 HYDROGEOLOGY

### 2.1 UT of Daman

Basalt is the main basement rock which occurs at variable depths in most parts of Moti Daman and also exposed at surface in the north west part of Daman namely in Marwad, Devka, Kadiya. Basaltic ridges having elevation of about 111m amsl are exposed in and around Kunta and Wankad villages. Basalt sheet rocks are exposed in river beds of Daman Ganga, Kalu and kolak rivers bordering UT of Daman. Alluvial deposits are found overlying the basalts, all along Moti Daman area and also in Dabhel and Kachigam areas having depth of 12 to 40m bgl. Alluvium deposits are river terrace type along the banks of river Daman Ganga.

The basalt occurs in the form of flows comprising massive and compact basalt in the bottom and gradually passes into vesicular basalt at the top. The basalts vary in colour from dark green to pink and show different sets of joints. All the joint systems are restricted to the individual flow seldom cutting across other flows. The surface weathering is characterised by spheroidal weathering.

Fig-02: UT of Daman\_Major Geoligal map



Ground water occurs in both the basaltic and alluvial formations. In Moti Daman area and Warkund, Dabhel and Kachigam areas of Nani Daman, alluvium forms the unconfined aquifer system. However, in Nani Daman area this aquifer has become desaturated and do not sustain irrigation/domestic requirement.

In alluvial formation ground water occurs in unconfined condition, water level ranging from 4m bgl to 8m bgl. The basaltic rock is encountered at variable depth of 20m bgl to 40m bgl underlying the alluvial formation. Ground water occurring in this aquifer gets recharged from rainfall infiltration and it is also assumed that the river Daman Ganga and other perennial rivers like Kalu and Kolak contribute to a large extent during monsoon period. The movement of ground water is controlled by the topographic features. The yield of the wells in both the basaltic and the alluvial formations are moderate, varying from 30 m<sup>3</sup> to 300m<sup>3</sup>/day.

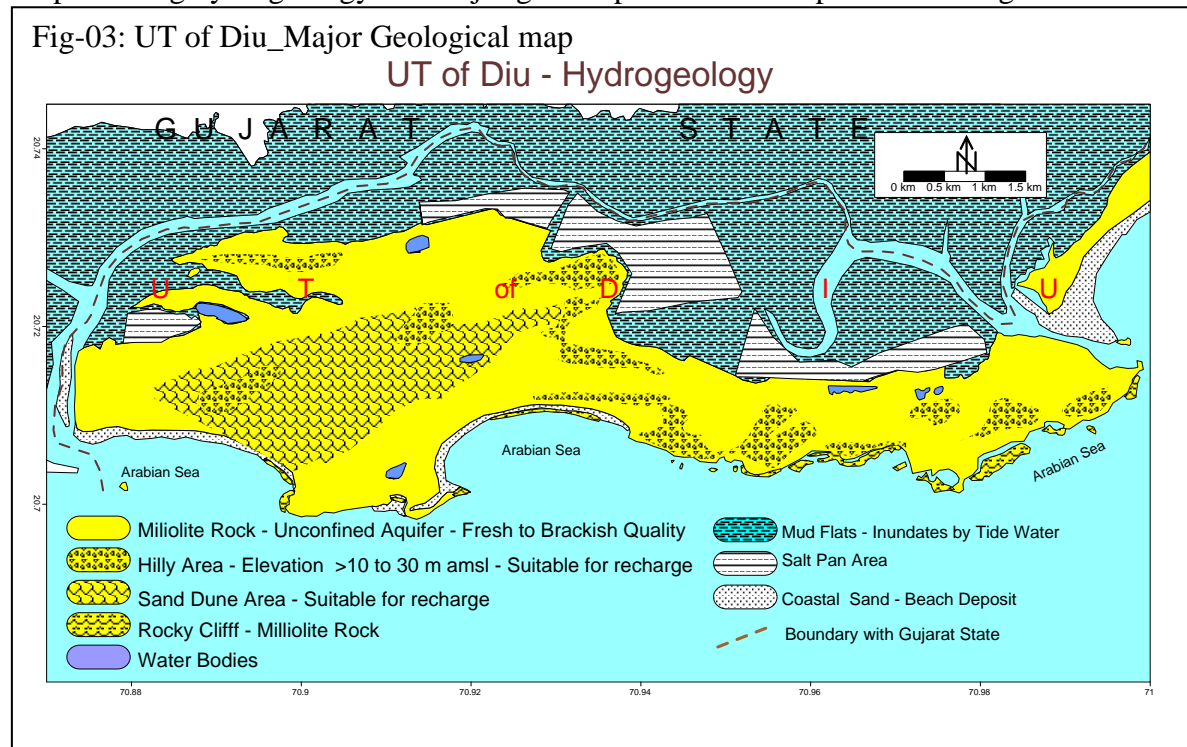
## 2.2 UT of Diu

Diu district is underlain by Miliolitic limestone of Upper Pleistocene age, which are sandy in nature and consist of varying proportions of calcium carbonate, shell fragments and other detrital materials. They have an N-S to NNW-SSE trend and usually dip gently towards east. This limestone possesses both primary as well as secondary porosity and is cavernous, friable in nature and forms good aquifers. Near the surface (1 – 2 m) the limestone is hard and compact due to calcification of the limestone, as calcium carbonate solutions has given rise to hard and compact curst. The solution activity has resulted in formation of caverns/cavities. The karstic activity is more predominant in the zone of water table fluctuation and in the lower parts, near the contact with underlying Gaj Formations. The Miliolitic limestone is underlain by Gaj Formation of Miocene period, having a thickness of more than 200m. The Gaj formation comprises upper yellowish white clays underlain by interbedded marls, calcareous sandstone, grit, impure (earthy) limestone and clays. (Phadtare, 1988). Pale gray or yellow are the predominant colours of the Gaj sediments. The base of Gaj Formation rests over the Deccan Trap Basalt. The west central part of Diu Island is covered by sand dunes of 10 to 20 m height, overlying milliolite rock.

The generalized geological succession in the area is as follows

Age	Formation	Lithology	Max. thickness/ Remarks
Recent to Pleistocene	Coastal Alluvium & Miliolite limestone	Sand, clays, Miliolite-limestone	40-50 m
Miocene (Tertiary)	Gaj beds	Clay, Marl, calc. sandstone, lime stone etc.	+ 200 m Not exposed
Upper Cretaceous to Eocene	Deccan Trap	Basaltic lava	not exposed

Map showing hydrogeology and major geomorphic features is presented in figure 1 below.



### 3.0 GROUND WATER SCENARIO

Systematic and regular monitoring of groundwater levels brings out the changes taking place in the groundwater regime. The maps so generated are of immense help for regional groundwater flow modelling which serves as a groundwater management tool to provide the necessary advance information to the user agencies to prepare contingency plans in case of unfavourable groundwater recharge situation. The data also has immense utility in deciding the legal issues arising out of conflicting interests of groundwater users.

The monitoring of ground water levels has been carried out at groundwater monitoring wells four times in a year simultaneously throughout the State during the following periods.

- May - 20<sup>th</sup> to 30<sup>th</sup> (water level of pre-monsoon period).
- August - 20<sup>th</sup> to 30<sup>th</sup> (peak monsoon water level).
- November - 1<sup>st</sup> to 10<sup>th</sup> (water levels of post-monsoon period).
- January - 1<sup>st</sup> to 10<sup>th</sup> (the recession stage of water level).

Water level data of the ground water monitoring wells collected during the year 2018 – 2019 has been utilized to prepare various maps showing depth to water level and fluctuation of water level. Depth to water level maps are useful in dealing with problems of water logging and artificial recharge, where the relative position of water level with reference to the ground surface is of critical importance. Water level fluctuation maps (rise or fall) are indispensable for estimation of change in storage in the aquifer.

For the purpose of presentation, the Union Territory of Daman & Diu has been described separately. The water level data of these open wells and piezometers are presented in the Annexure II.

The data is analysed for each set of measurement, and report prepared which include following maps to understand the groundwater regime in the state.

1. Depth to water level
2. Seasonal fluctuation - water level fluctuation in comparison to pre-monsoon.
3. Annul fluctuation - water level fluctuation in comparison to same month in the previous year.
4. Decadal fluctuation - water level fluctuation in the month of measurement with reference to the decadal average for the same month.

### 3.1 Depth to Water Level (Unconfined Aquifer)

A analysis was done to understand the water level behaviours of the ground water monitoring wells in the different categories of the water levels during every monitoring period and the same is depicted in **Fig. 6**.

#### 3.1.1 Depth to Water Level May 2018

In the pursuance of Fig no. 4 reveals that 80% of monitoring stations (table- 5) of the state falls in the water levels ranges 5 - 20m bgl. Water levels below of 5 mbgl are observed in 20% of stations of the UT of Daman & Diu.

The depth to water level is in the range of 3.24 m bgl at Jempore to 11.80 m bgl at Morwad of Daman and 4.15 m bgl at Gomtimata to 7.21m bgl at Pothiabapa in Diu.

WELL WISE CATEGORISATION OF DEPTH TO WATER LEVEL - MAY 2018										
Sl.No.	District	No. of Wells Analysed	DTWL in mbgl		No of well in different Ranges					
			Min	Max	0 to 2 (m)	2 to 5(m)	5 to 10(m)	10 to 20(m)	20 to 40(m)	>40(m)
1	DAMAN	7	3.24	11.80	0	1	5	1	0	0
					0.00%	14.29%	71.43%	14.29%	0.00%	0.00%
2	DIU	3	4.15	7.21	0	1	2	0	0	0
					0.00%	33.33%	66.67%	0.00%	0.00%	0.00%
<b>UT of Daman &amp; Diu</b>		<b>10</b>	<b>3.24</b>	<b>11.80</b>	<b>0</b>	<b>2</b>	<b>7</b>	<b>1</b>	<b>0</b>	<b>0</b>
					<b>0.00%</b>	<b>20.00%</b>	<b>70.00%</b>	<b>10.00%</b>	<b>0.00%</b>	<b>0.00%</b>

RODC, CGWB - WCR, Ahmedabad

#### 3.1.2 Depth to Water Level August 2018

During August 2018 (Fig-05) the depth to water level of unconfined aquifer range from 0.74 to 6.04m bgl. Details of depth to water level in different range, from 0-2 m, 2 to 5 m, 5 to 10 m, 10 to 20m, 20 to 40 m and more than 40 mbgl are presented in table – 6. The perusal of the depth to water level reveals that 78% of the monitoring stations falls in the ranges of 0 to 5 mbgl whereas 5 to 10 mbgl water level are observed in 22% of the well in UT of Daman & Diu.

Fig-04:DTW Map of UT of Daman and Diu, May 2018

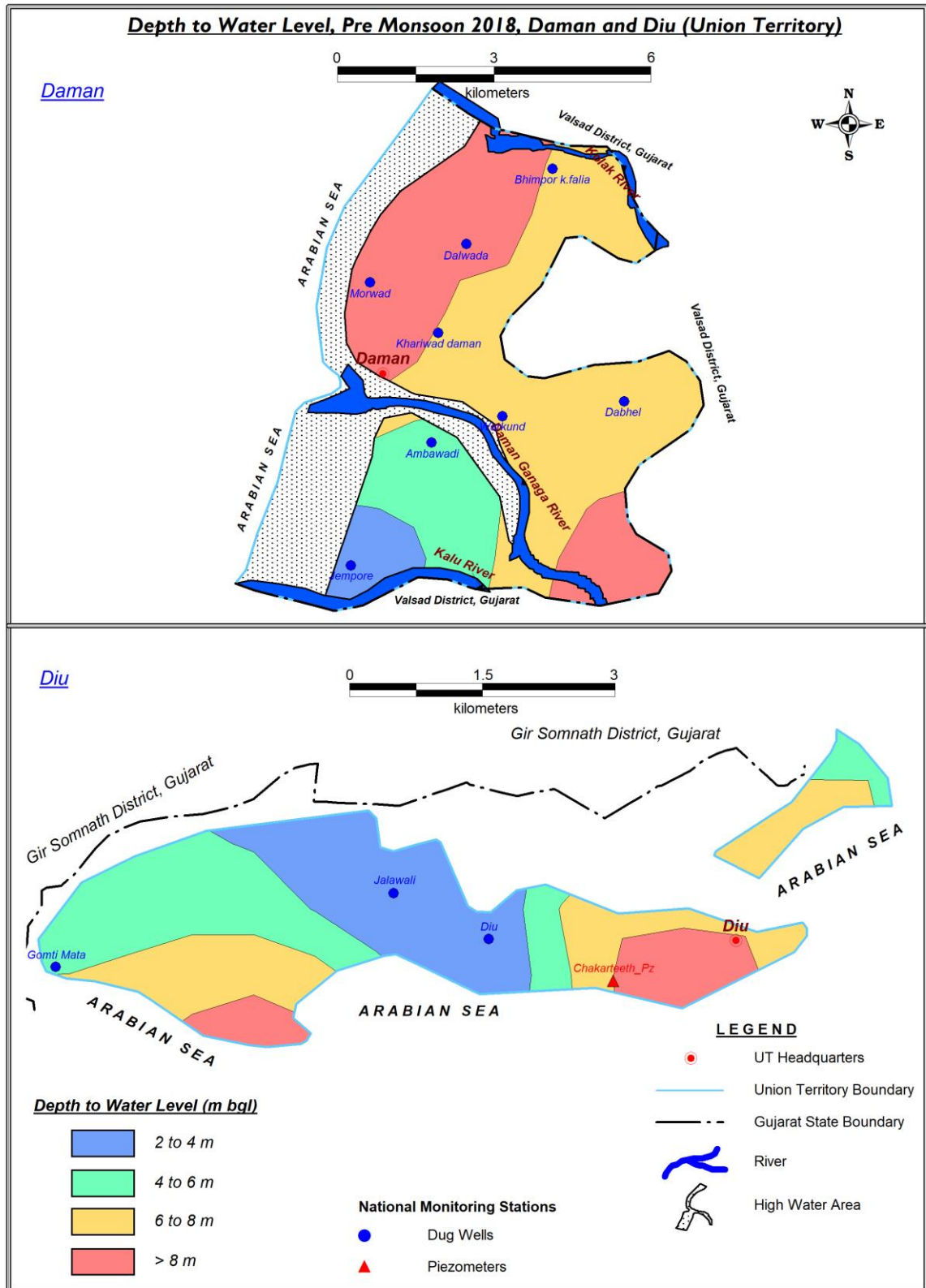
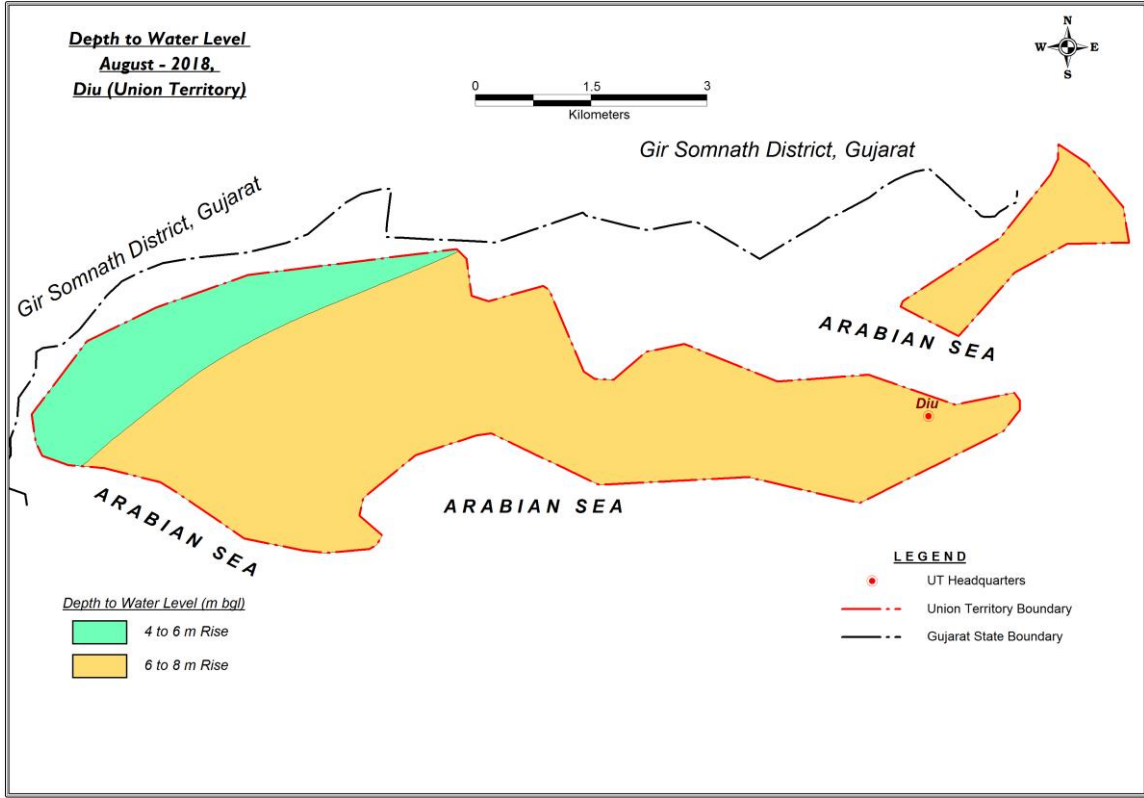


Fig-05: DTW Map of UT of Daman and Diu, August 2018





The depth to water level in Daman ranges from 0.74mbgl at Warkund to 3.09m bgl at Ambawadi in Daman where as in Diu area depth to water levels ranges from 3.96m bgl at Gomtimata to 6.04m bgl at Chakarteeth.

WELL WISE CATEGORISATION OF DEPTH TO WATER LEVEL - AUGUST 2018										
Sl.No.	District	No. of Wells Analysed	DTWL in mbgl		No of well in different Ranges					
			Min	Max	0 to 2 (m)	2 to 5(m)	5 to 10(m)	10 to 20(m)	20 to 40(m)	>40(m)
1	DAMAN	6	0.74	3.09	5	1	0	0	0	0
					83.33%	16.67%	0.00%	0.00%	0.00%	0.00%
2	DIU	3	3.96	6.04	0	1	2	0	0	0
					0.00%	33.33%	66.67%	0.00%	0.00%	0.00%
<b>Daman &amp; Diu</b>		<b>9</b>	<b>0.74</b>	<b>6.04</b>	<b>5</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>
					<b>55.56%</b>	<b>22.22%</b>	<b>22.22%</b>	<b>0.00%</b>	<b>0.00%</b>	<b>0.00%</b>
RODC, CGWB - WCR, Ahmedabad										

### 3.1.3 Depth to Water Level November 2018

The depth to water level of unconfined aquifer ranges from 0.55m bgl to 6.16m bgl during November 2018 (**Fig 6 and table no 7**). The perusal of the water level reveals that 82% of the total well analysed has water level less than 5m bgl, in UT of Daman & Diu. Water levels of 5 to 10m bgl are observed in 18% of the well.

The depth to water level is within the range of 0.55m bgl (Warkund) to 2.57m bgl (Ambawadi) in Daman and minimum water level in Diu is 2.49m bgl at (Jalawadi) to 6.16 m bgl at Pothiabapa.

WELL WISE CATEGORISATION OF DEPTH TO WATER LEVEL - NOVEMBER 2018										
Sl.No.	District	No. of Wells Analysed	DTWL in mbgl		No of well in different Ranges					
			Min	Max	0 to 2 (m)	2 to 5(m)	5 to 10(m)	10 to 20(m)	20 to 40(m)	>40(m)
1	DAMAN	7	0.55	2.57	5	2	0	0	0	0
					71.43%	28.57%	0.00%	0.00%	0.00%	0.00%
2	DIU	4	2.49	6.16	0	2	2	0	0	0
					0.00%	50.00%	50.00%	0.00%	0.00%	0.00%
<b>Daman &amp; Diu</b>		<b>11</b>	<b>0.55</b>	<b>6.16</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>
					<b>45.45%</b>	<b>36.36%</b>	<b>18.18%</b>	<b>0.00%</b>	<b>0.00%</b>	<b>0.00%</b>
RODC, CGWB - WCR, Ahmedabad										

### 3.1.4 Depth to Water Level January 2019

A perusal of **Fig 7 and Table 8** reveals that the depth to water level of unconfined aquifer ranges from 2.7 to 8.16m bgl during January 2019. Details of depth to water level in different range, i.e. from 0-2 m, 2 to 5 m, 5 to 10 m, 10 to 20m, 20 to 40 m and more than 40 mbgl is presented in table – 8. The perusal of the Depth To Water map reveals that about 38% of the total well analysed falls in the water level range of 0 to 5m bgl where as water level of 5 to 10 mbgl is observed in 62% of UT of Daman & Diu.

The depth to water level is within the range of 2.70 (Jempore) to 7.25m bgl (Dalwada) in Daman whereas in Diu water level ranges 3.28m bgl at Jalawadi to 8.96 mbgl in Pothia Bapa.

Fig-06: DTW Map of UT of Daman and Diu, November 2018

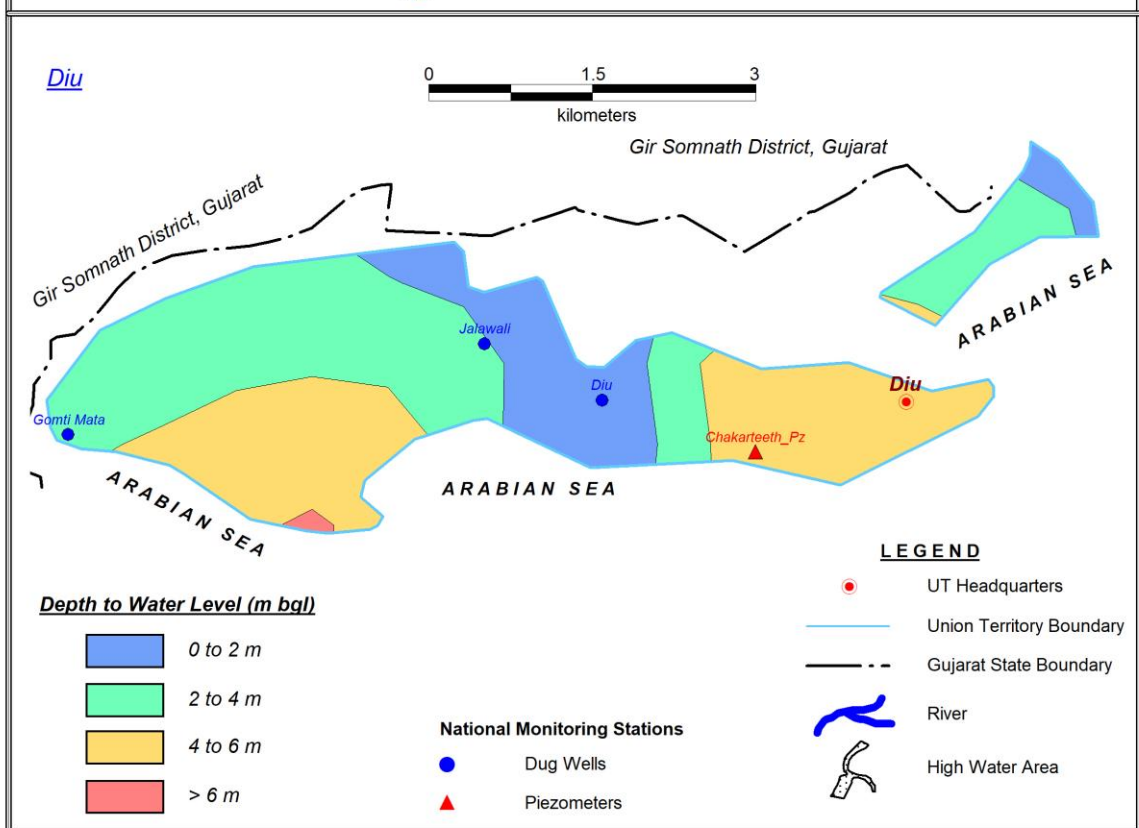
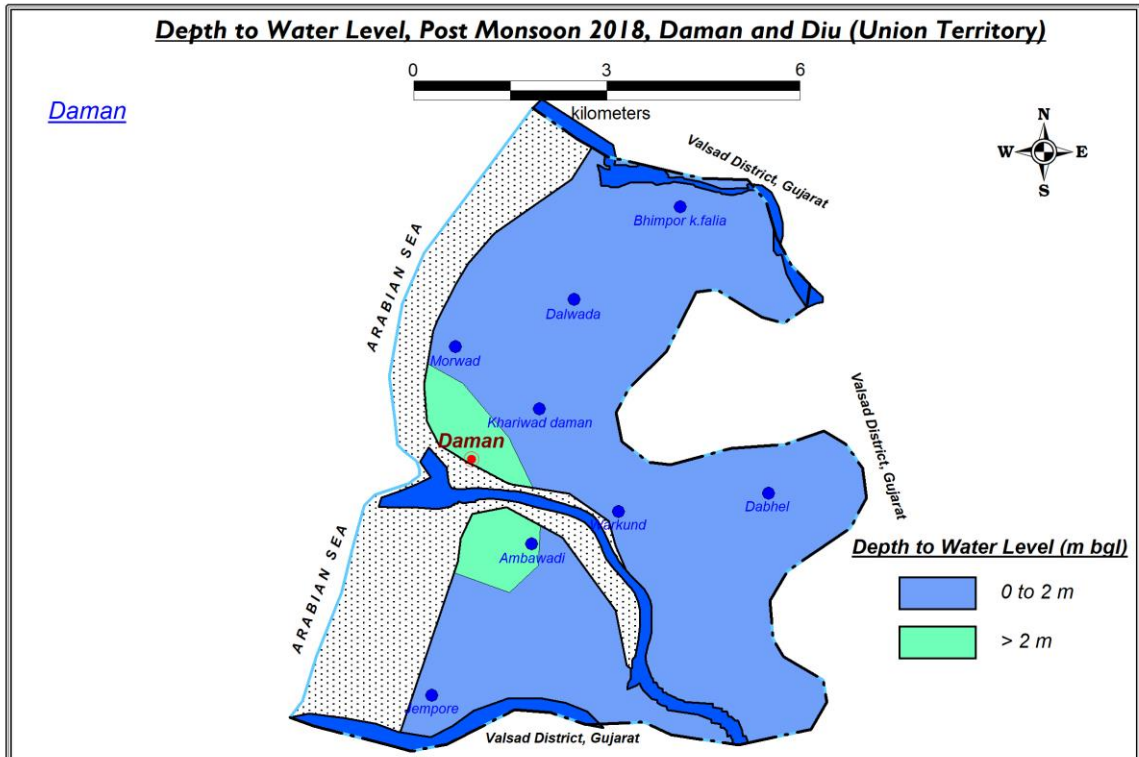
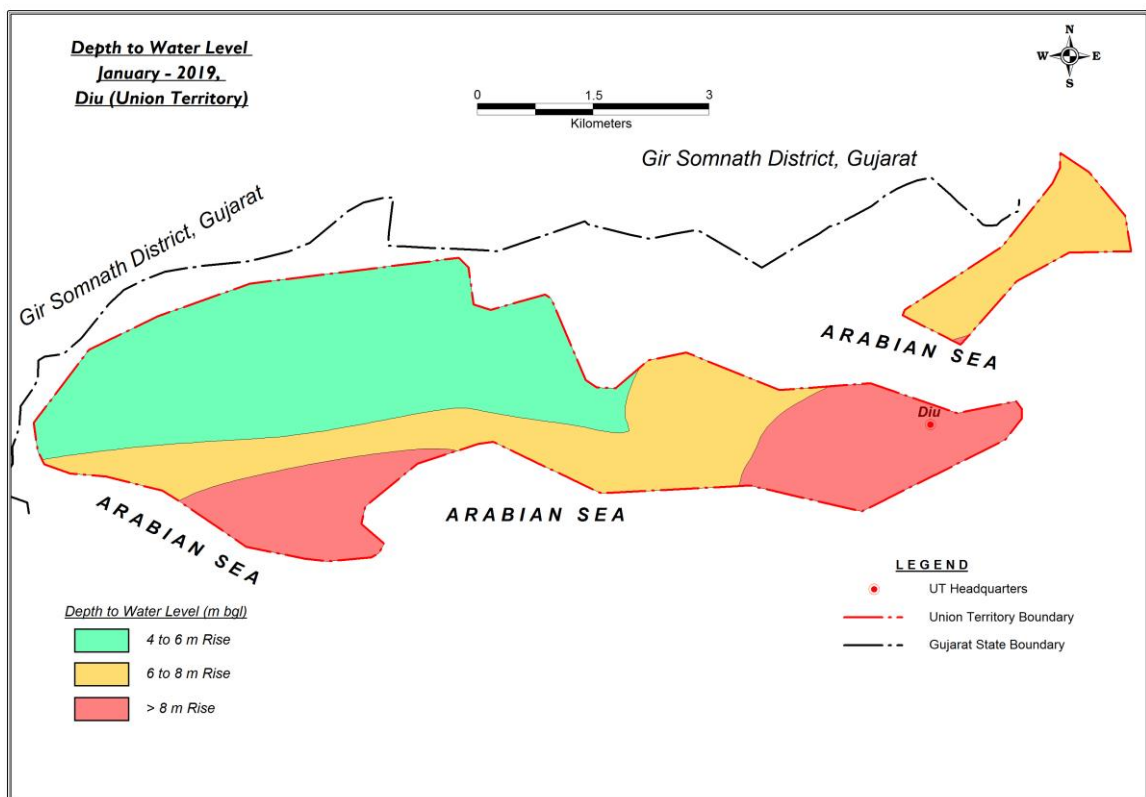
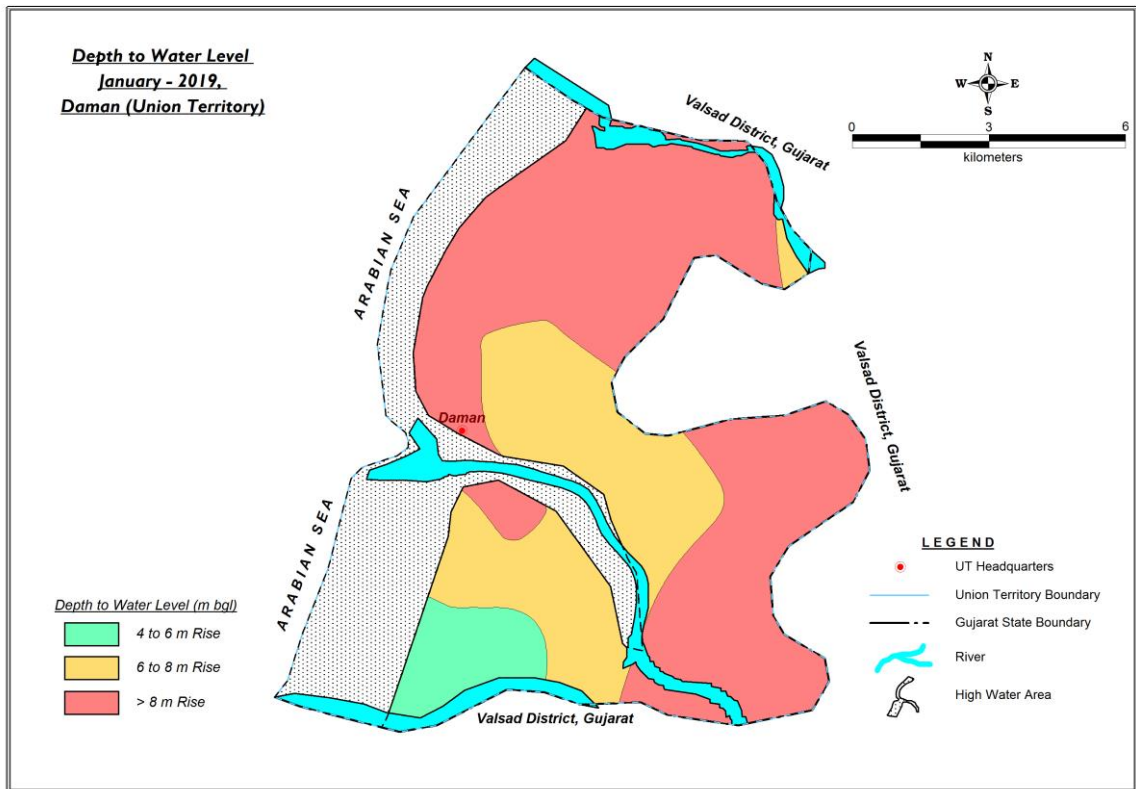


Fig-07: DTW Map of UT of Daman and Diu, January 2019



WELL WISE CATEGORISATION OF DEPTH TO WATER LEVEL - JANUARY 2019										
Sl.No.	District	No. of Wells Analysed	DTWL in mbgl		No of well in different Ranges					
			Min	Max	0 to 2 (m)	2 to 5(m)	5 to 10(m)	10 to 20(m)	20 to 40(m)	>40(m)
1	DAMAN	8	2.70	7.25	0	2	6	0	0	0
					0.00%	25.00%	75.00%	0.00%	0.00%	0.00%
2	DIU	5	3.28	8.96	0	3	2	0	0	0
					0.00%	60.00%	40.00%	0.00%	0.00%	0.00%
<b>Daman &amp; Diu</b>		<b>13</b>	<b>2.70</b>	<b>8.96</b>	<b>0</b>	<b>5</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>0</b>
					0.00%	38.46%	61.54%	0.00%	0.00%	0.00%
RODC, CGWB - WCR, Ahmedabad										

### 3.2 Seasonal Water Level Fluctuation

To study the effect of monsoon on the groundwater regime and subsequent utilisation of groundwater for various needs like agriculture, irrigation, Domestic etc., changes in depth to water levels with respect to May data are studied. The change in groundwater in the region over different periods is presented and a summary of each observation is discussed below.

#### 3.2.1 May 2018 to August 2018

A perusal of **Table 9** reveals that 100% of the total wells in UT of Daman & Diu shows a rise in water level. Rise in water level are observed in the range of 0 to 2 m in 22% of wells, 2 to 4 m in 33% of well and morethan 4m in 45% of wells monitored in the UT of Daman and Diu. The maximum rise of 6.91m is recorded at Dalwada in Daman whereas the maximum rise of 2.01m is recorded at Pothiabapa in Diu. In UT of Daman only rise in water level is observed in August 2018 as compared to May 2018.

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2018 TO AUGUST 2018														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	6	2.15	6.91	-	-	0	2	4	0	0	0	6	0
							0.00%	33.33%	66.67%	0.00%	0.00%	0.00%		
2	Diu	3	0.19	2.01	-	-	2	1	0	0	0	0	3	0
							66.67%	33.33%	0.00%	0.00%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>9</b>	<b>0.19</b>	<b>6.91</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>9</b>	<b>0</b>
							22.22%	33.33%	44.44%	0.00%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

#### 3.2.2 May 2018 to November 2018

The seasonal water level fluctuation shows rise in 100% of the total wells monitored in the UT of Daman & Diu area during the Pre and Post Monsoon of 2018 (Fig-8). In the UT, the maximum rise of 9.78m is recorded at Morwad in Daman whereas the maximum rise of 1.05m is observed at Pothiabapa in Diu. (Table 10).

Fig:08: Seasonal fluctuation of water level from May 2018 to November 2018

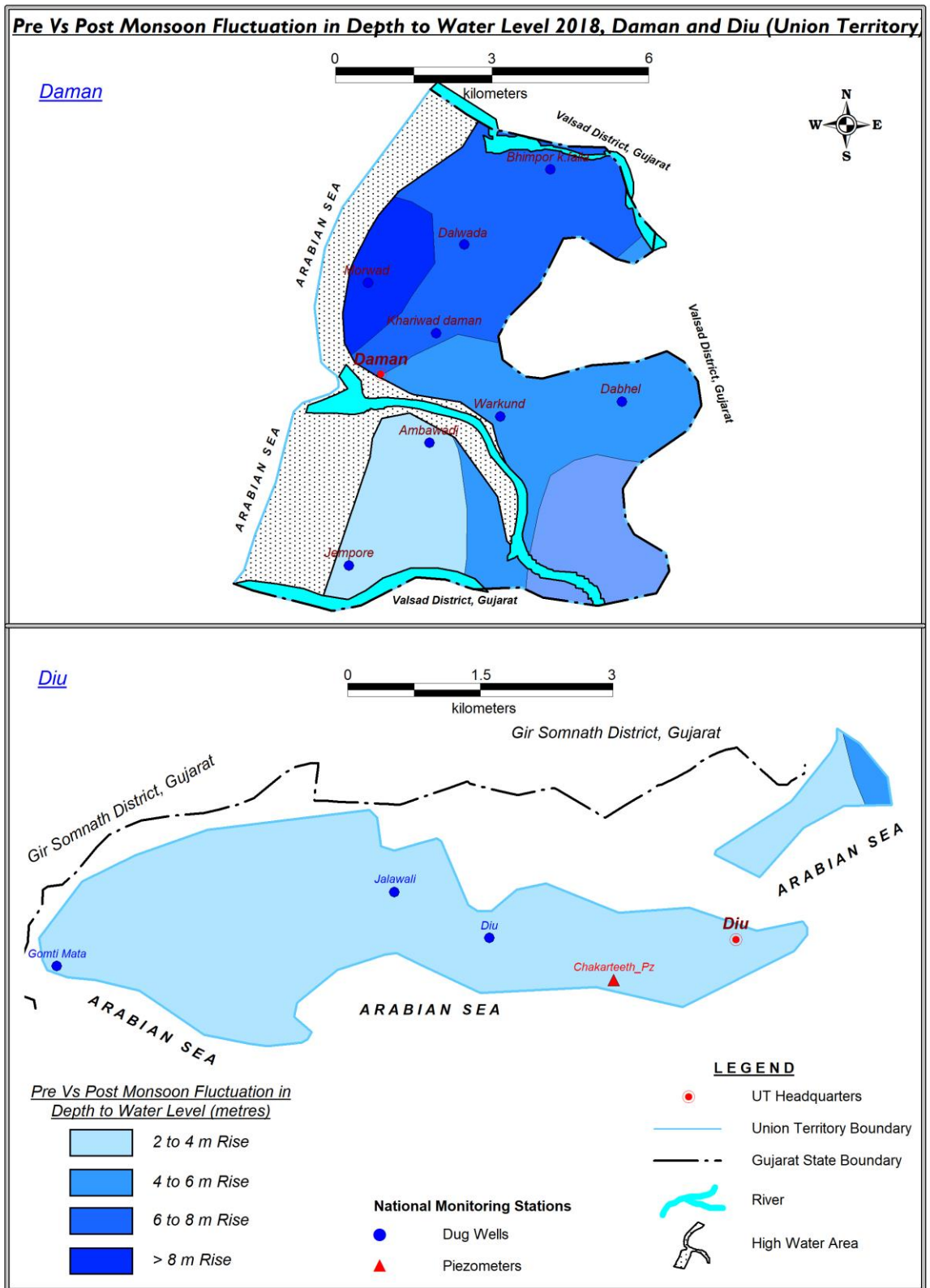


Table -10

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2018 TO NOVEMBER 2018														
Sr. No.	District Name	No of well analys	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	2.44	9.78	-	-	0	2	5	0	0	0	7	0
							0.00%	28.57%	71.43%	0.00%	0.00%	0.00%		
2	Diu	3	0.25	1.05	-	-	3	0	0	0	0	0	3	0
							100.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>10</b>	<b>0.25</b>	<b>9.78</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>2</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>10</b>	<b>0</b>
							30.00%	20.00%	50.00%	0.00%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.2.3 May 2018 to January 2019

A perusal of **Table 11** reveals that about 60% of the total well in the UT of Daman & Diu area have recorded rise in water level between May 2018 and January 2019. Fall in water level is observed in 40% of well analysed.

In UT of Daman, rise in water level ranges from 0.54 to 5.2 m bgl where as fall in water level ranges from 0.22 to 0.81m bgl. In UT of Diu, rise in water level is 0.14 where as fall ranges from 0.05 to 1.75 m bgl.

Table -11

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2018 TO JANUARY 2019														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.54	5.2	0.22	0.81	3	1	1	2	0	0	5	2
							42.86%	14.29%	14.29%	28.57%	0.00%	0.00%		
2	Diu	3	0.14	0.14	0.05	1.75	1	0	0	2	0	0	1	2
							33.33%	0.00%	0.00%	66.67%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>10</b>	<b>0.14</b>	<b>5.2</b>	<b>0.05</b>	<b>1.75</b>	<b>4</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>6</b>	<b>4</b>
							40.00%	10.00%	10.00%	40.00%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.3 Annual Water Level Fluctuation

Annual Fluctuation in the water levels of the ground water monitoring wells during different monitoring periods were analysed and dicussed below

#### 3.3.1 May 2017 to May 2018

A perusal of **Table 12** reveals that 30% of the total monitoring stations of UT shows a rise in water level. Rise of 0-2 m is observed in about 20% of total well of the UT. Fall in water level is observed mainly in the range of 0-2 m and covers about 50% of total well of the UT.

In UT of Daman, rise of water level range from 0.04 to 0.26m bgl where as fall is range from 0.28 to 0.52m bgl. In UT of Diu, rise of water level is 2.07m bgl where as fall is range from 0.01 to 0.12m bgl.

Table - 12

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2017 TO MAY 2018														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.04	0.26	0.28	0.52	2	0	0	3	0	0	2	3
							28.57%	0.00%	0.00%	42.86%	0.00%	0.00%		
2	Diu	3	2.07	2.07	0.01	0.12	0	1	0	2	0	0	1	2
							0.00%	33.33%	0.00%	66.67%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>10</b>	<b>0.04</b>	<b>2.07</b>	<b>0.01</b>	<b>0.52</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>5</b>
							20.00%	10.00%	0.00%	50.00%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.3.2 August 2017 to August 2018

A perusal of **Table 13** reveals that 44% of total monitoring well in the UT of Daman & Diu shows a rise in water level fall observed in 56%. Rise in water level with in range of 0 – 2 m is observed in about 33% of well. Fall in the range of 0 – 2 m experienced by by 56% of well of the UT.

In the UT, rise in water level range from 0.21 to 2.61 m bgl in Daman where as 1.1 to 1.1m bgl in Diu. Fall in water level range from 0.35 to 0.46m bgl in Daman where as 0.11 to 0.49m bgl in Diu.

Table -13

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN AUGUST 2017 TO AUGUST 2018														
Sr. No.	District Name	No of well analyse	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	6	0.21	2.61	0.35	0.46	2	1	0	3	0	0	3	3
							33.33%	16.67%	0.00%	50.00%	0.00%	0.00%		
2	Diu	3	1.1	1.1	0.11	0.49	1	0	0	2	0	0	1	2
							33.33%	0.00%	0.00%	66.67%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>9</b>	<b>0.21</b>	<b>2.61</b>	<b>0.11</b>	<b>0.49</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>5</b>
							33.33%	11.11%	0.00%	55.56%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.3.3. November 2017 to November 2018

A perusal of **Table 14** reveals that 100% of total monitoring wells shows a rise in water level of the UT of Daman & Diu. In the UT of Daman, rise of water level is from 0.6 to 3.98m bgl where as in UT of Diu, rise is from 0.5 to 1.68m bgl.

Table -14

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN NOVEMBER 2017 TO NOVEMBER 2018														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.6	3.98	-	-	3	4	0	0	0	0	7	0
							42.86%	57.14%	0.00%	0.00%	0.00%	0.00%		
2	Diu	4	0.5	1.68	-	-	4	0	0	0	0	0	4	0
							100.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>11</b>	<b>0.5</b>	<b>3.98</b>	<b>0</b>	<b>0</b>	<b>7</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>11</b>	<b>0</b>
							63.64%	36.36%	0.00%	0.00%	0.00%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.3.4 January 2018 to January 2019

A perusal of **Table 15** reveals that out of total monitoring wells, 42% shows a rise where as 58% shows fall in water level of the UT of Daman & Diu. Rise in water level mainly within range of 0 – 2m is observed in about 42% of the total well in the UT of Daman and Diu. The rise of water level range is 0.42 m and fall is range from

0.76 to 1.89m bgl in UT of Daman where as in UT of Diu, rise of water level range from 0.31 to 1.04m bgl and fall is 2.07m bgl.

Table -15

CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN JANUARY 2018 TO JANUARY 2019														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.42	0.42	0.76	1.89	1	0	0	6	0	0	1	6
							14.29%	0.00%	0.00%	85.71%	0.00%	0.00%		
2	Diu	5	0.31	1.04	2.07	2.07	4	0	0	0	1	0	4	1
							80.00%	0.00%	0.00%	0.00%	20.00%	0.00%		
<b>UT of Daman &amp; Diu</b>		<b>12</b>	<b>0.31</b>	<b>1.04</b>	<b>2.07</b>	<b>2.07</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>6</b>	<b>1</b>	<b>0</b>	<b>5</b>	<b>7</b>
							41.67%	0.00%	0.00%	50.00%	8.33%	0.00%		
RODC, CGWB - WCR, Ahmedabad														

### 3.4 Long Term Ground Water Scenario

Long-term behaviour of water levels was studied by analysing the data for decadal average water levels and fluctuation of present year water level with respect to decadal average water levels. Maps showing variation in water level scenario over the decade 2007-16 for May, August, November and 2008-17 for January have been prepared to evaluate the long term changes in the groundwater regime.

#### 3.4.1 Decadal Average Depth to Water Level

Maps showing depth to water level scenario over the decade 2008-17 have been prepared to evaluate the long term changes in the groundwater regime. Average depth to water level data is given in Annexure IV and distribution of the same is discussed below.

##### 3.4.1.1 Pre-monsoon Water Levels (2009-18)

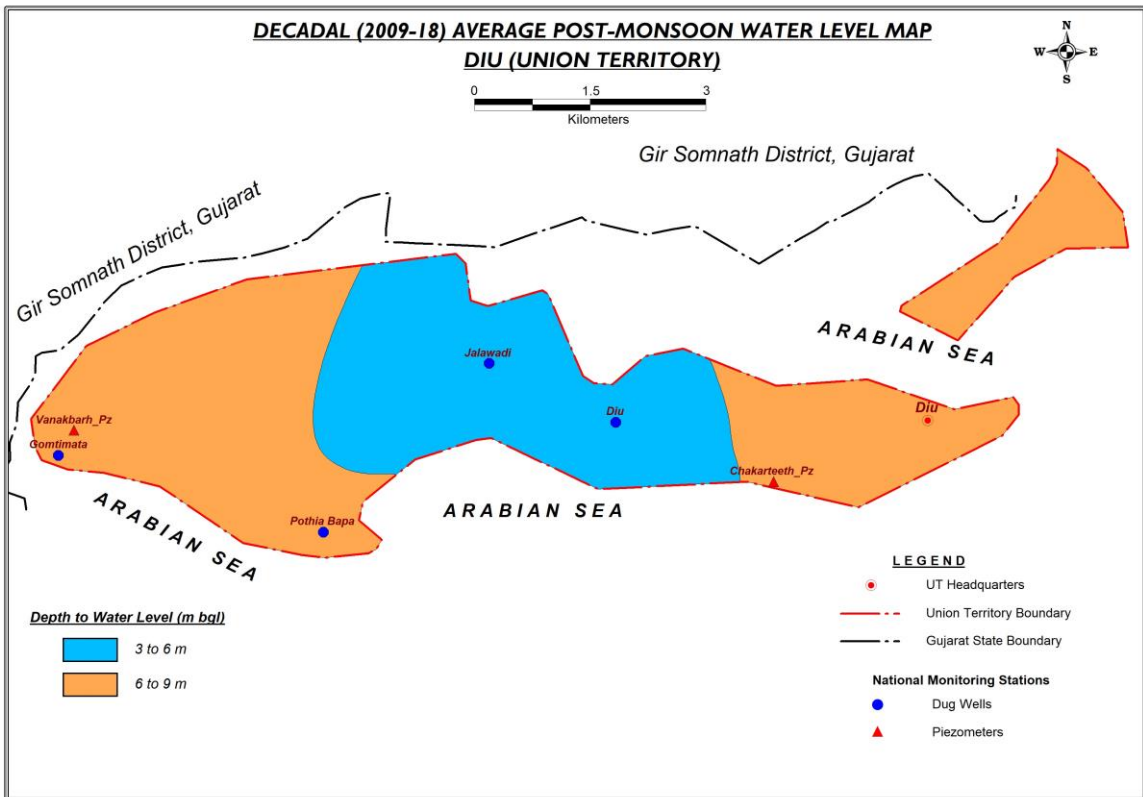
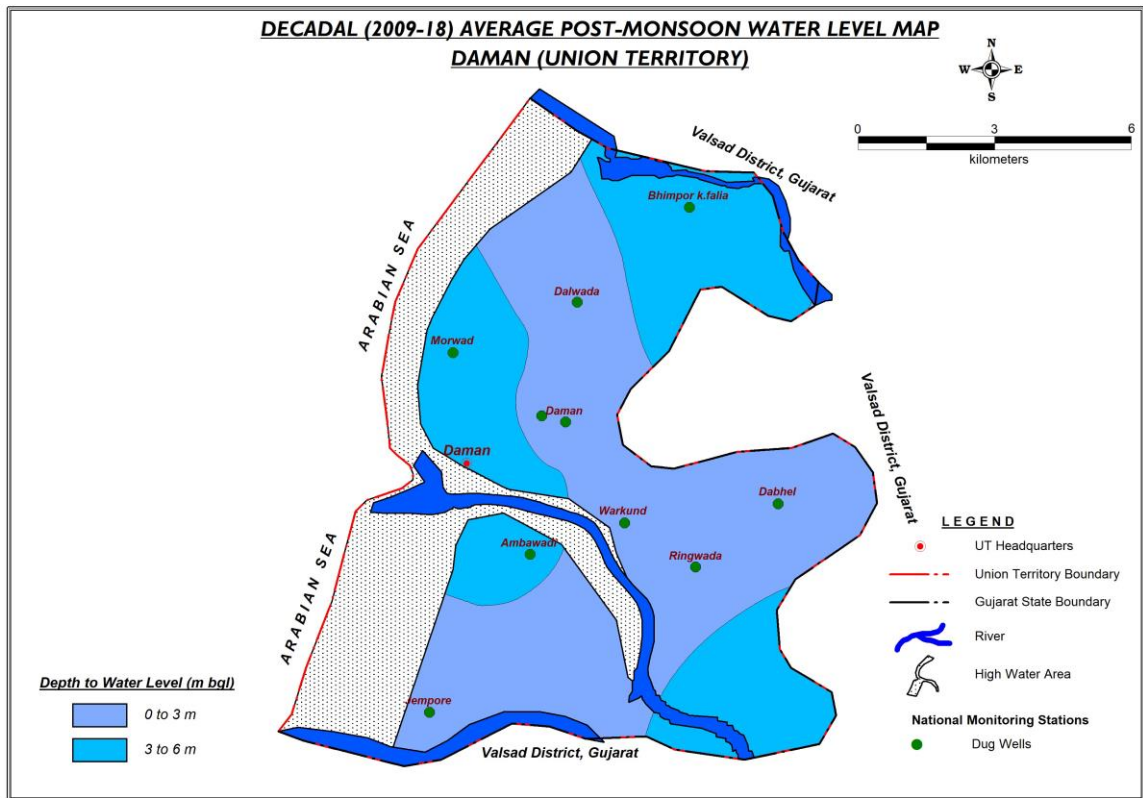
Decadal average water level map for the period May 2009 to May 2018 reveals that the decadal average water level in UT is generally 3.52 to 8.64m bgl in Daman and 3.80 to 6.31 m bgl in Diu. (Annexure III)

##### 3.4.1.2 Post-monsoon Water Levels (2009-18)

Decadal average water level map for the period November 2009 to November 2018 (**Fig. 09**) reveals that in major part of UT, the decadal average water level is mostly in the range of 1.61 m to 4.70m bgl in Daman where as in Diu it is 6.16m bgl. (Annexure III)



**Fig. 09: Decadal water level map during postmonsoon 2009 to 2018**



### 3.4.1 Decadal Variations

Long-term behaviour of water levels was studied by analysing fluctuation of present year water level with respect to decadal average water levels. Variation in water level scenario over the decade 2007-16 for May, August, November and 2008-17 for January have been prepared to evaluate the long term changes in the groundwater regime.

#### 3.4.2.1 Decadal average of May (2008-2017) to May 2018

A comparison of the water level of the May 2018 with the average water level of the May for last one decade (2008 - 2017) reveals that there is a fall of 60% of the wells monitored. Rise and fall is mostly in the range of 0 to 2m. Fall of more than 4m is observed in 10% of well. The maximum rise of 1.9m is recorded Diu whereas the maximum fall of 4.12m is recorded in Daman.

In Union Territory both rise and fall is observed. In Daman the maximum rise of 0.46 m and fall 4.12 m are observed. In Diu 1.92 m rise and fall is 0.13 m recorded.

**Table-16**

**WELL WISE CATEGORISATION OF CHANGES IN WATER LEVEL DURING MAY 2018 WITH RESPECT TO DECADAL AVERAGE OF MAY (2008 TO 2017)**

Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.09	0.46	0.43	4.12	3	0	0	2	1	1	3	4
							42.86%	0.00%	0.00%	28.57%	14.29%	14.29%		
2	Diu	3	1.92	1.92	0.01	0.13	1	0	0	2	0	0	1	2
							33.33%	0.00%	0.00%	66.67%	0.00%	0.00%		
UT of Daman & Diu		10	0.09	1.92	0.01	4.12	4	0	0	4	1	1	4	6
							40.00%	0.00%	0.00%	40.00%	10.00%	10.00%		

#### 3.4.2.2 Decadal average of August (2008 to 2017) to August 2018

A comparison of the water level of the August 2018 with the average water level of the August for last one decade (2008-2017) **Table 17** reveals that there is a rise in (56% of well analysed) and fall in 44% of well analysed. Rise and fall is mostly in the range of 0 to 2 m. The maximum rise of 1.1m is recorded in Diu whereas the maximum decline of 0.37m is recorded in Daman.

In Union Territory of Daman, rise in water level ranges from 0.09 to 0.17 m and fall is from 0.01 to 0.37 m where as in UT of Diu, rise in water level ranges from 0.05 to 1.1.

WELL WISE CATEGORISATION OF CHANGES IN WATER LEVEL DURING AUGUST 2018 WITH RESPECT TO DECADAL AVERAGE OF AUGUST (2008 To 2017)														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	6	0.09	0.17	0.01	0.37	2	0	0	4	0	0	2	4
							33.33%	0.00%	0.00%	66.67%	0.00%	0.00%		
2	Diu	3	0.05	1.1	-	-	3	0	0	0	0	0	3	0
							100.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
UT of Daman & Diu		9	0.05	1.10	0.01	0.37	5	0	0	4	0	0	5	4
							55.56%	0.00%	0.00%	44.44%	0.00%	0.00%		

### 3.4.2.3 Decadal average of November(2008-2017) to November 2018

A comparison of the water level of the November 2018 with the average water level of the November for last one decade (2008-2017) **Table 18** reveals that there is a rise in water level in the UT (100% of total well analysed). Rise is mostly in the range of 0 to 4m. The maximum rise of 2.99m is recorded in Daman whereas the minimum rise of 0.1m is recorded in Diu.

In Union Territory of Daman rise of water level in range of rise vary from 0.91 to 2.99 where as 0.1 to 1.77 in Diu.

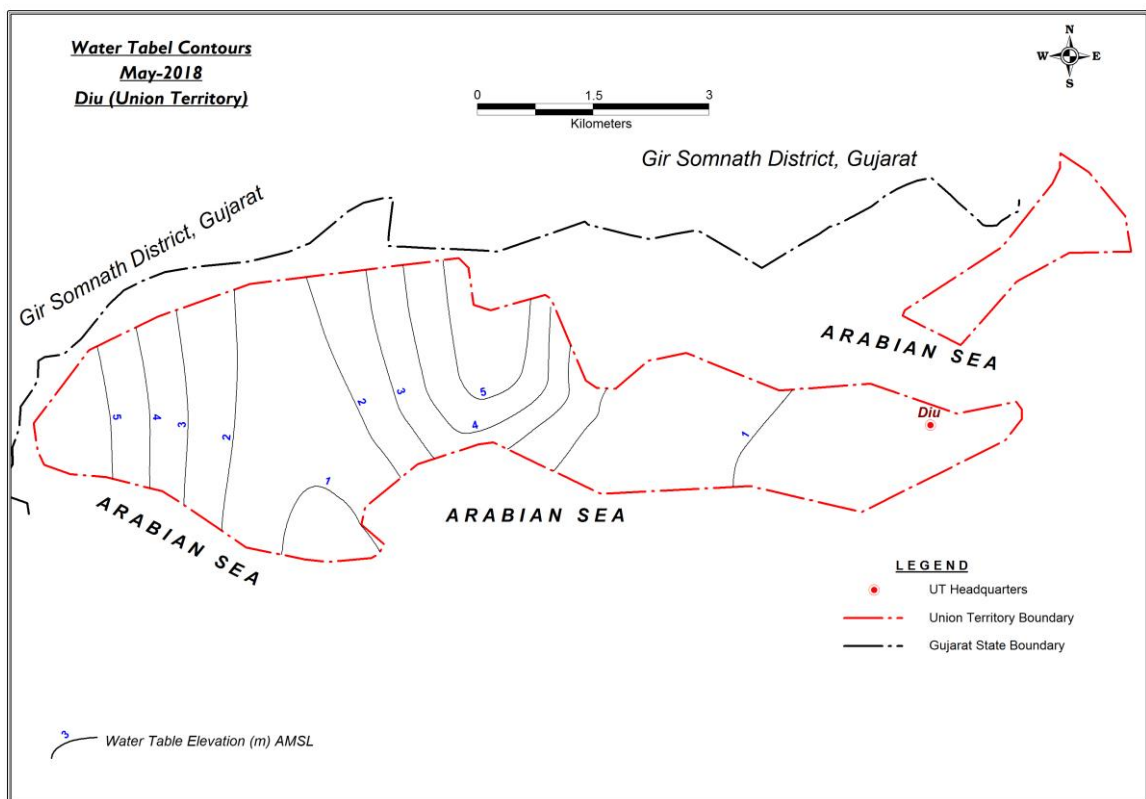
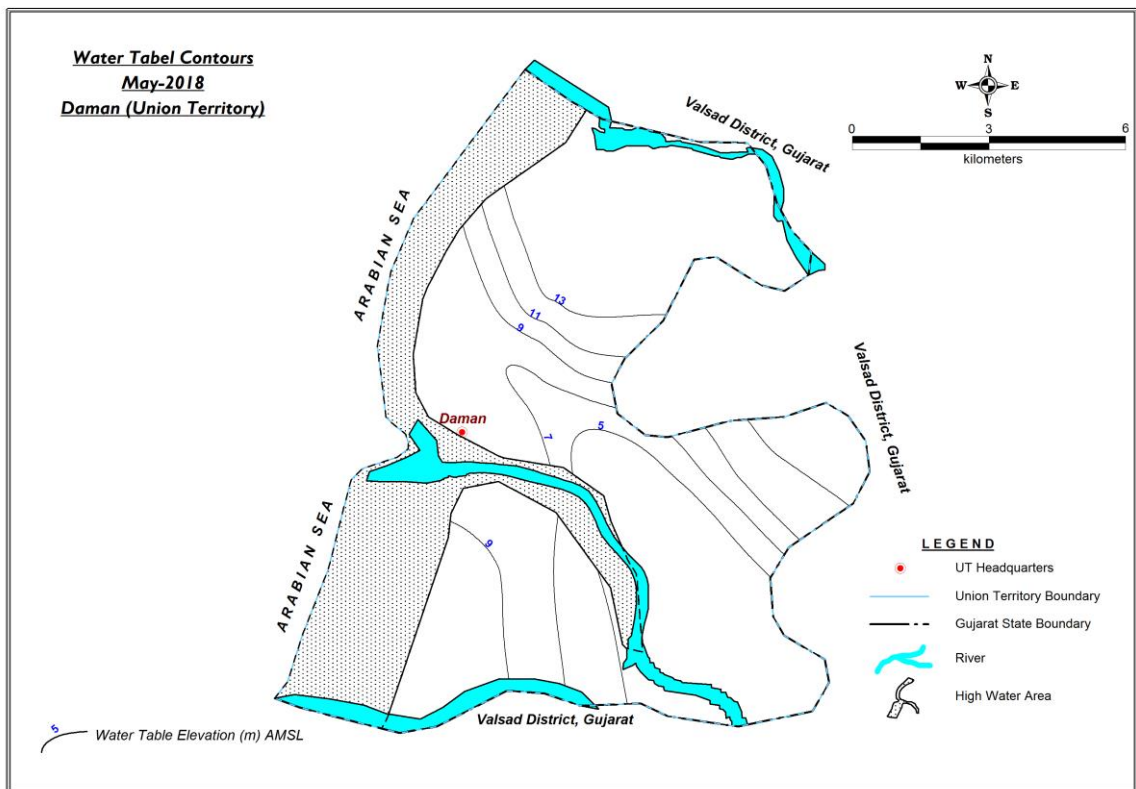
WELL WISE CATEGORISATION OF CHANGES IN WATER LEVEL DURING NOVEMBER 2018 WITH RESPECT TO DECADAL AVERAGE OF NOVEMBER (2008 To 2017)														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	7	0.91	2.99	-	-	6	1	0	0	0	0	7	0
							85.71%	14.29%	0.00%	0.00%	0.00%	0.00%		
2	Diu	4	0.1	1.77	-	-	4	0	0	0	0	0	4	0
							100.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
UT of Daman & Diu		11	0.10	2.99	0.00	0.00	10	1	0	0	0	0	11	0
							90.91%	9.09%	0.00%	0.00%	0.00%	0.00%		

### 3.4.2.4 Decadal average of January(2009-2018) to January 2019

A comparison of the water level of the January 2019 with the average water level of the January for last one decade (2009-2018) **Table 19** reveals that there is a fall in water level in the UT (77% of total well analysed). Rise and fall is mostly in the range of 0 to 2m. The maximum rise of 1.66m is recorded in Diu whereas the maximum fall of 3.27m is recorded in Daman.

WELL WISE CATEGORISATION OF CHANGES IN WATER LEVEL DURING JANUARY 2019 WITH RESPECT TO DECADAL AVERAGE OF JANUARY (2009 To 2018)														
Sr. No.	District Name	No of well analysed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation						Total No. of Wells	
			Rise		Fall		Rise			Fall			Rise	Fall
			Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
1	Daman	8	-	-	0.45	3.27	0	0	0	5	3	0	0	8
							0.00%	0.00%	0.00%	62.50%	37.50%	0.00%		
2	Diu	5	0.23	1.66	0.1	2.1	3	0	0	1	1	0	3	2
							60.00%	0.00%	0.00%	20.00%	20.00%	0.00%		
UT of Daman & Diu		13	0.23	1.66	0.10	3.27	3	0	0	6	4	0	3	10
							23.08%	0.00%	0.00%	46.15%	30.77%	0.00%		

Fig-10: Groundwater table contours of UT of Daman and Diu May 2018



In Union Territory of Daman & Diu, both rise and fall is observed. The rise range from 0.23 to 1.66m and fall 0.1 to 2.1m in Diu where as fall of water level is 0.45 to 3.27 in Daman

### **3.5 Water Table Scenario in May 2018**

The water table map for pre-monsoon period (Fig. 10) reveals that the water table in different parts of the UT ranges between 0.79m to 14.05m amsl (Annexure II). The water table mostly follows the topography of the area. Water table in UT of Daman vary from 3.14m to 14.05m amsl. Ground water flow direction is south westward in UT of Daman. In UT of Diu, water table elevations vary from 0.79m to 5.85m a msl flowing in a south and southeast direction.

## **4. HYDROCHEMISTRY**

Hydrochemistry is an interdisciplinary science that deals with the chemistry of water in the natural environment. The classical use of chemical characteristics in hydrochemistry is to provide information about the regional distribution of water qualities. At the same time, hydrochemistry has a potential use for tracing the origin and history of water. The hydrochemistry can also be of immense help in yielding information about the environment through which water has circulated. Hydrochemistry can be helpful in knowing about residence time, flow path and aquifer characteristics, as the chemical reactions are time and space dependent.

The diverse physiographic, climatic, topographic and geologic conditions have given rise to diversified groundwater situations in different parts of UT of Daman and Diu. The groundwater quality of UT is variable and complex as its quality is influenced by local geology, coastal salinity, inherent salinity, and contamination and heavy withdrawal of groundwater. High chemical concentrations mostly occur in coastal regions due to seawater intrusion brought by upcoming or reversal in hydraulic gradient.

### **4.1 Groundwater Quality Monitoring**

A systematic plan for conducting water quality monitoring is called Monitoring Programme, which includes monitoring network design, preliminary survey, resource estimation, sampling, analysis, data management & reporting. Monitoring of groundwater quality is an effort to obtain information on chemical quality through representative sampling in different hydro geological units. Groundwater is commonly tapped from phreatic aquifers through dug wells in a major part through springs and hand pumps in hilly areas.

Central Ground Water Board (WCR), Ahmedabad has monitored a total number of 9 water samples collected during May 2018, for basic parameters determining pH, EC, TDS, CO<sub>3</sub>, HCO<sub>3</sub>, Cl, NO<sub>3</sub>, SO<sub>4</sub>, F, Ca, Mg, TH, Alkalinity, Na, K and SAR, involving use of instruments such as pH meter, EC meter, flame photometer, UV/ Visible Spectrophotometer and titrimetric methods. Further 9 water

samples were collected for heavy metal analysis from the all locations of NHNS. The samples for analysis was collected in 250ml Polypropylene (Tarson make) sample bottles and treated with hydrochloric acid to make the final concentration of acid 0.01 N. The Iron analysis was conducted us by Atomic Absorption spectrophotometer.

## 4.2 Ground water quality scenario in the state

From the analytical results it has been observed that majority of water samples collected from observation wells of CGWB in a major part of the state fall under desirable or permissible category and hence are suitable for drinking purposes. However, a small percentage of well waters are found to have concentrations of some constituents beyond the permissible limits. Such waters are not fit for human consumption and are likely harmful to health on continuous use. Based on the results it is found that groundwater in the UT is mostly of calcium bicarbonate type when the Electrical conductivity is below 750uS/cm.

There are mixed cation and mixed anions type groundwater in the UT when the electrical conductance is between 750 and 3200 uS/cm and waters with electrical conductance more than 3200 uS/cm are of sodium chloride type.

The overall results of hydro chemical analysis are attached in **Annexure IV**.

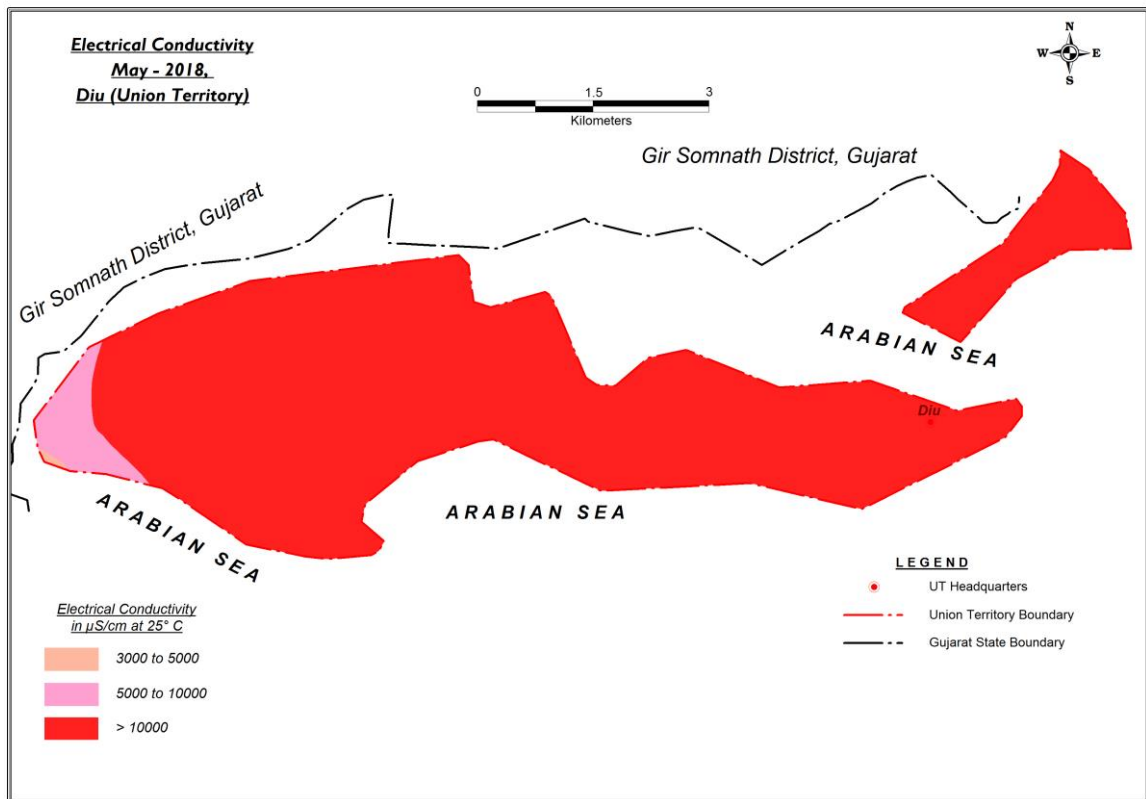
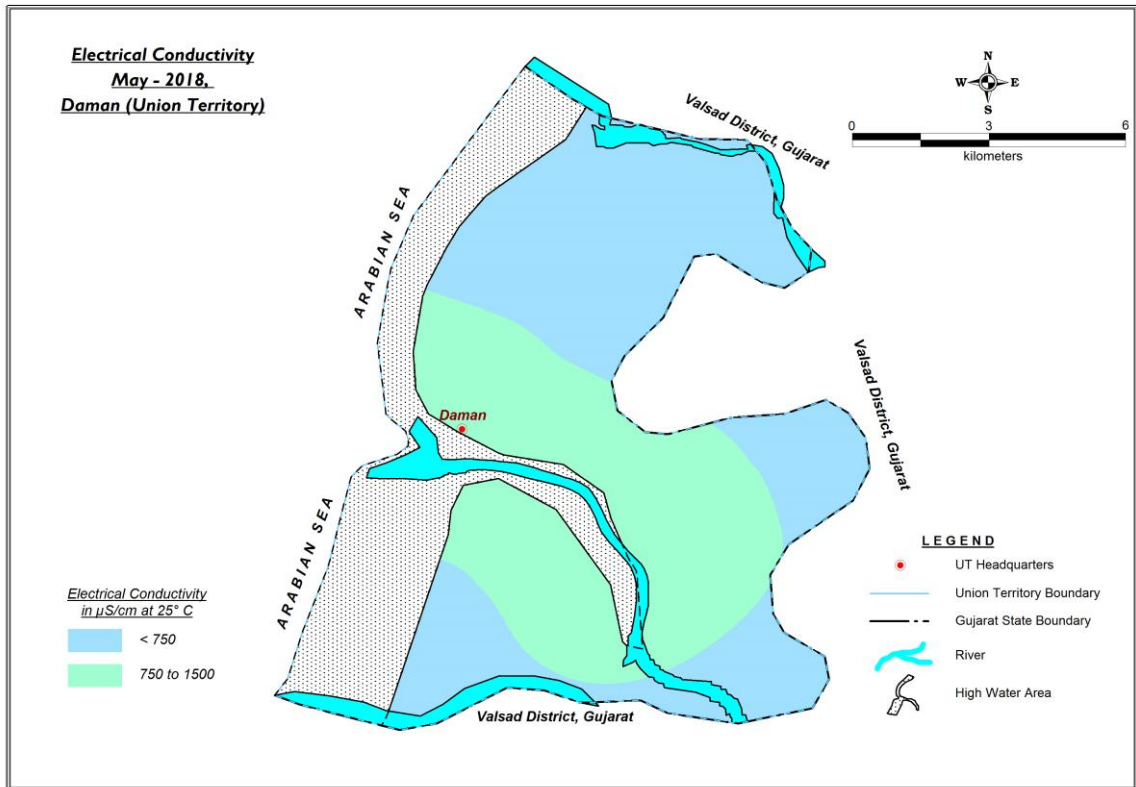
**Major quality findings are described as under: -**

### 4.2.1 The Electrical conductivity

Electrical conductivity or Total dissolved solids or Salinity is the saltiness or dissolved salt contents of a water body. Different substances dissolve in water giving it taste and odour. In fact, human beings have developed senses, which are able to evaluate the potability of water. Electrical conductivity represents total number of cations and anions present in groundwater, indicating ionic mobility of different ions, total dissolved solids and saline nature of water. In general water having EC < 1500 uS/cm, is considered as fresh water, EC 1500 – 15000uS/cm, is considered as Brackish water and > 15000uS/cm is considered as saline water. In general in most parts of the state the EC value is found to be very high i.e. 3200uS/cm to 15000uS/cm and more. It was observed that out of 9 water samples, 4 samples show EC value more than 3200 uS/cm, which indicates the gravity of salinity problem in the area in UT of Diu. The map showing of electrical conductivity in state is represented in **Fig 11**.

A close observation of the **Annexure-V** reveals High **EC Values** > 3200 uS/cm have been found in 4 number of samples out of 9 total number of samples analyzed indicating saline nature of water in most part of the UT of Diu. Location with more than 3200 uS/cm of EC values are Gomtimata 3951, Jholawadi 34500, Bucharwada 22800, Vachhawadi 15720 in **UT of Diu**, having EC in the more than 3200 uS/cm. In UT of Daman, water is almost fresh with respect to EC and salinity found with in 3200 uS/cm.

Fig-11: Isocontour map of EC of UT of Daman and Diu



#### 4.2.2 Chloride

Chloride is present in all natural waters being highly soluble and moves freely through soil and rock. In groundwater Chloride content is mostly below 250 mg/l except in cases where inland salinity is prevalent and in coastal areas. BIS have recommended a desirable limit of 250mg/l of chloride in drinking water; this concentration limit can be extended to 1000 mg/l of chloride in cases where no alternative source of water with desired concentration is available. The map showing distribution of Chloride in the state is represented in **Fig 12**.

A close observation of the **Annexure-IV**, High **Chloride** > 1000mg/L have been found in 3 numbers of samples out of 9 total numbers of samples analyzed indicating saline nature of water in UT of Diu. The maximum chloride value is observed at Jholawadi 4964, Bucharwada 4808, Vachhawadi 5142 mg/l in UT of Diu. In UT of Daman, most of the other places chloride problem is not eminent.

#### 4.2.3 Nitrate

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved nitrogen in the form of nitrate is the most common contaminant of groundwater. Nitrate in groundwater generally originates from non point sources such as leaching of chemical fertilizers and animal manure, groundwater pollution from septic and sewage discharges etc. It is difficult to identify the natural and man-made sources of nitrogen contamination of ground water. Some chemical and microbiological processes such as nitrification and denitrification also influence the nitrate concentration in ground water. The map showing distribution of nitrate in the state is represented in **Fig 13**.

As per the BIS standard for drinking water the maximum desirable limit of nitrate concentration in groundwater is 45 mg/l .Though nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental health concern arising from increased risks of methaemoglobinemia particularly to infants. Adults can tolerate little higher concentration.

Nitrate value have been found in the range of 3 to 130 mg/l where **high Nitrate** > 45mg/L, ( **Annexure IV**) have been found in 1 number of samples out of 9 total number of samples analyzed at Gomtimata 130 mg/l indicating high nitrate pollution due to use of nitrogen containing fertilizer, domestic and agriculture waste and man made anthropogenic activities.

Other places having nitrate < 45mg/l is no problem with respect to nitrate pollution.



Fig-12: Isocontor map of Chloride (May 2018) of UT of Daman and Diu

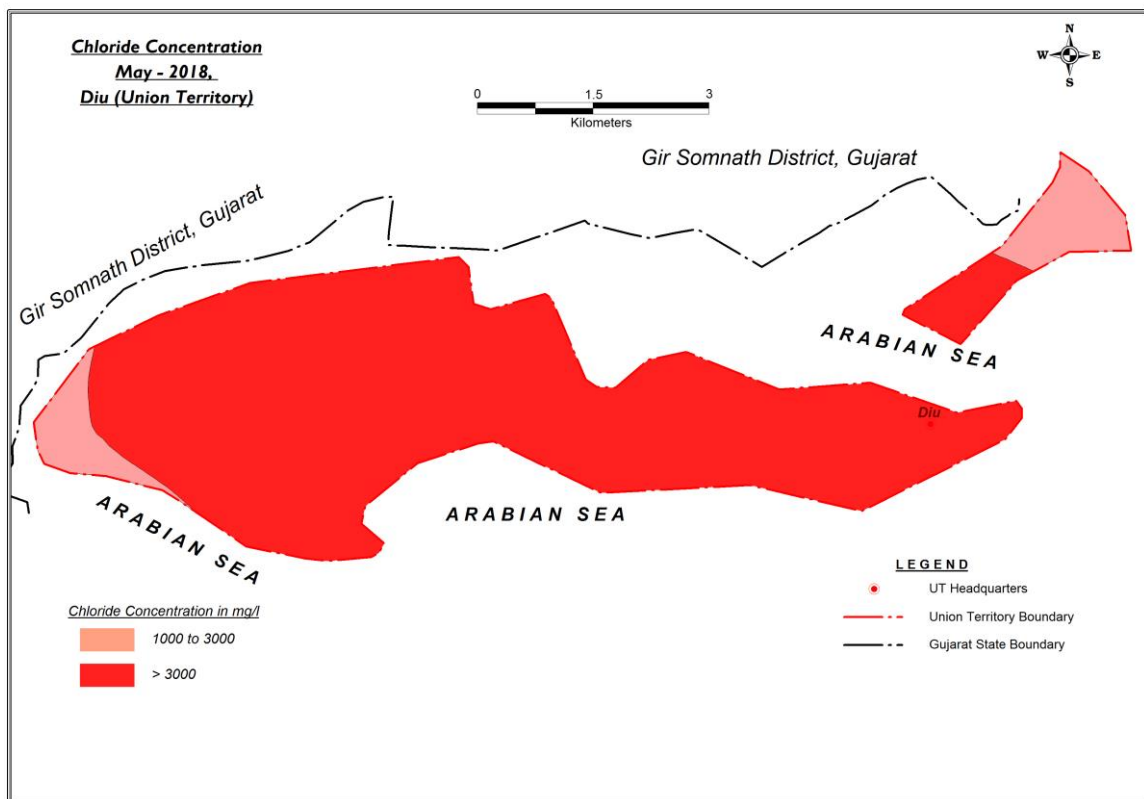
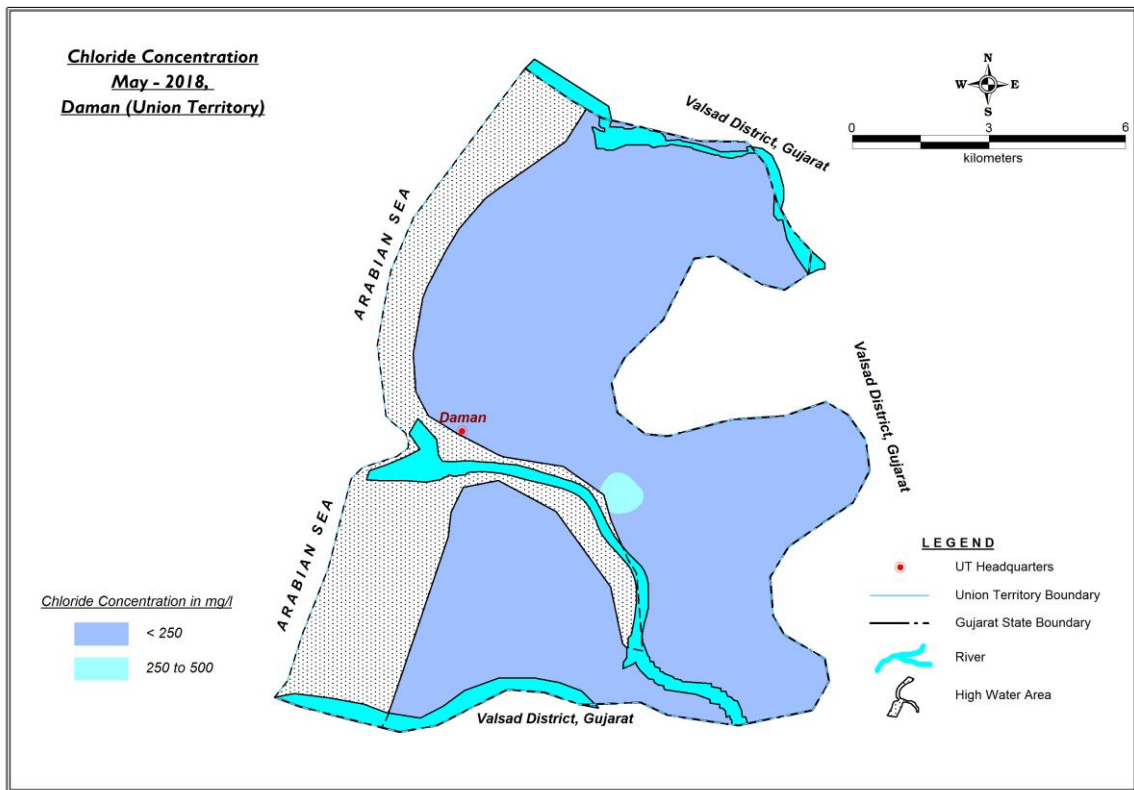


Fig-13: Map of Nitrate concentration (May 2018) of UT of Daman and Diu

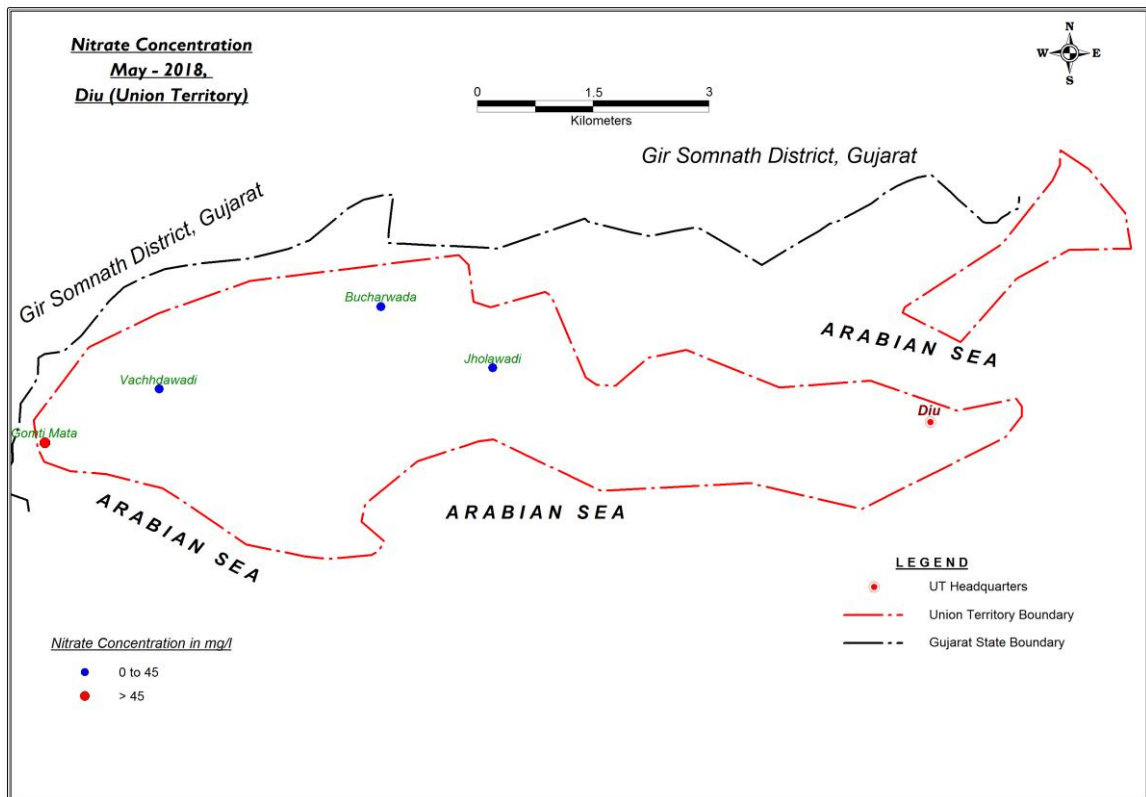
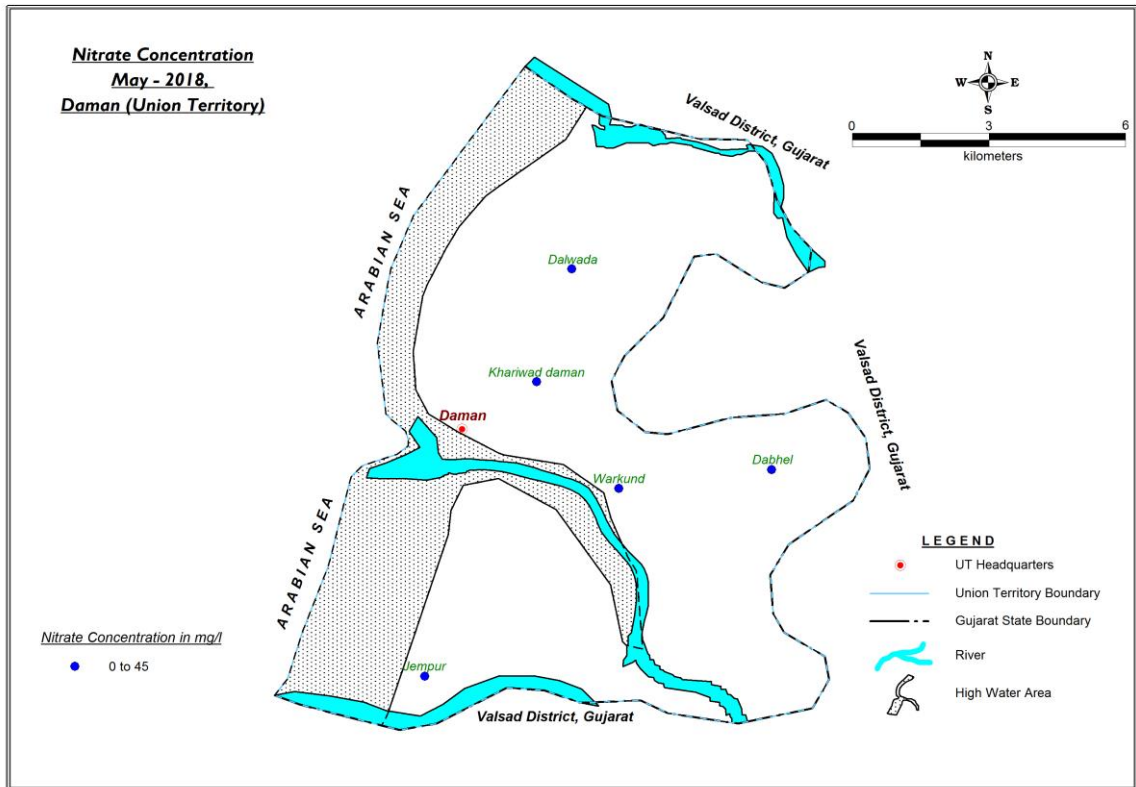
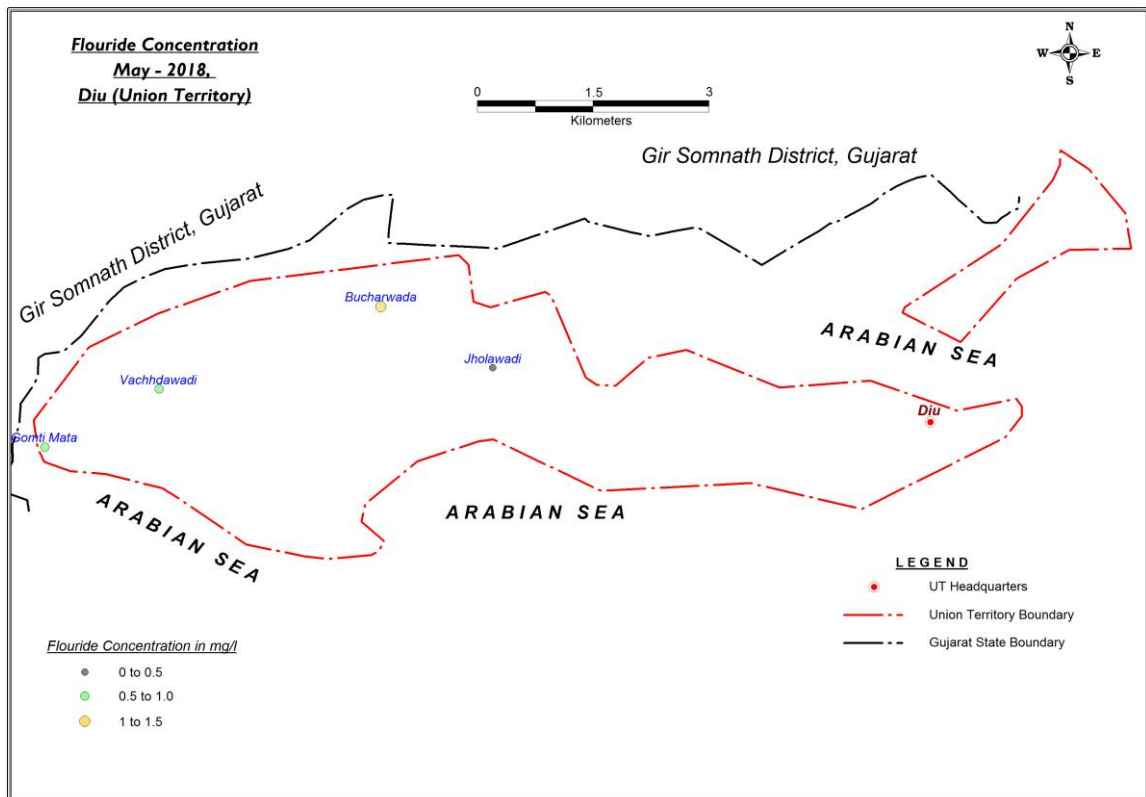
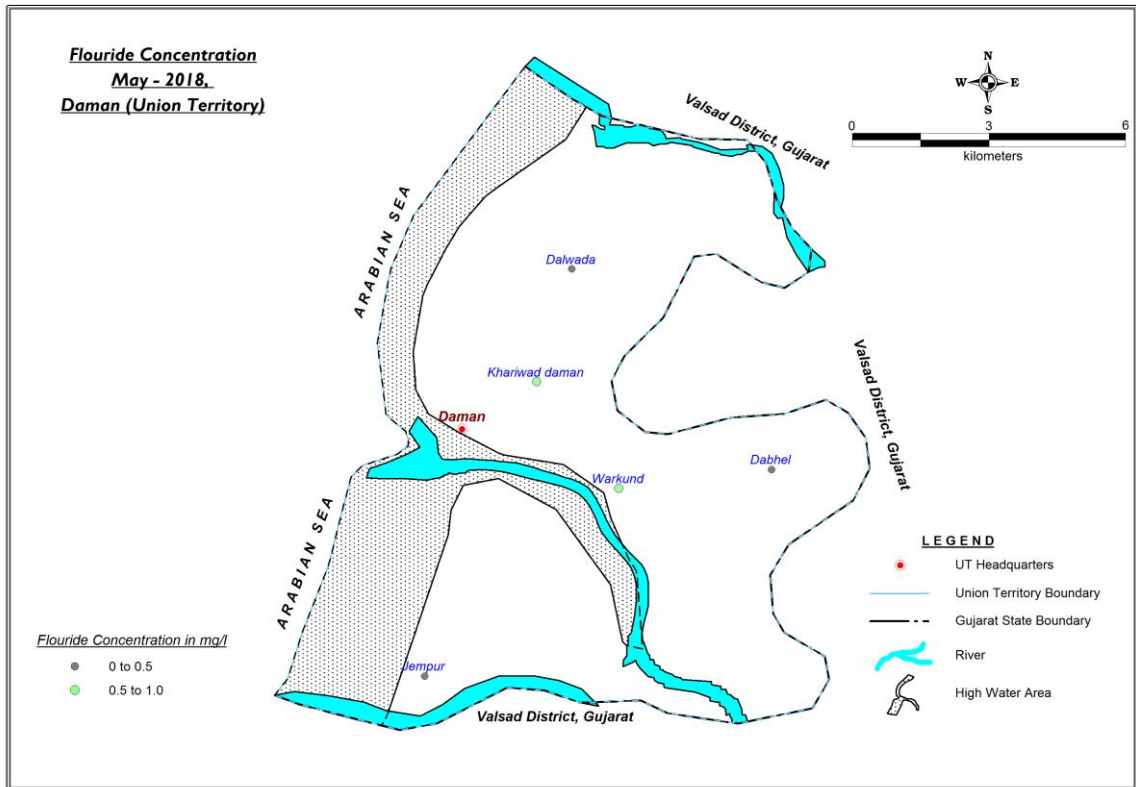


Fig-14: Map of Flouride concentration (May 2018) of UT of Daman and Diu



#### 4.2.4 Fluoride

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rocks. It exists in the form of fluorides in a number of minerals of which fluorspar, cryolite, fluorite & fluorapatite are the most common.

Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in groundwater in small amount. The type of rocks, climatic conditions, nature of hydro geological strata and time of contact between rock and the circulating groundwater affect the occurrence of fluoride in natural water. Presence of other ions particularly bicarbonate and calcium ions also affects the concentration of fluoride in groundwater. The map showing distribution of Fluoride in the state is represented in **Fig 14**.

It is well known that small amount of fluoride (>1.0 mg/l) have proven to be beneficial in reducing tooth decay. Community water supplies commonly are treated with sodium fluoride or fluorosilicates to maintain fluoride level ranging from 0.25 to 1.04 mg/l have been observed in the UT o Daman and Diu areas.

#### 4.2.5 Heavy Metal Analysis

##### Iron

Iron is a common constituent in soil and groundwater. It is present in water either as soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air the water turns cloudy due to oxidation of ferrous iron into reddish brown ferric oxide.

The concentration of iron in natural water is controlled by both physico-chemical and microbiological factors. It is contributed in ground water mainly from weathering of ferruginous minerals of igneous rocks such as hematite, magnetite and sulphide ores of sedimentary and metamorphic rocks. The permissible iron concentration in groundwater is less than 1.0mg/l as per the BIS Standard for drinking water. The map showing distribution of Iron in the state is represented in **Fig 15**.

A total number of 9 water samples from selected Groundwater monitoring wells were collected separately for iron analysis after filtration and hydrochloric acid treatment (Annexure\_V). Iron values ranges from 0.0096 to as high as 0.4752 ppm. Samples at Dabhel 0.4521, Dalwada 0.4752 and Warku 0.3056 in Daman found to contain Fe value > 0.3 ppm (Annexure V). Rest of the samples may be treated as totally safe with regard to iron pollution.

##### Chromium

Chromium values ranges from 0 to as high as 0.0491 ppm. Out of 9 samples, all samples have been found to contain Cr value > 0.05 ppm (Annexure V) which shows within desirable limit as BIS 2012 standard may be treated safe.

##### Copper

Copper values ranges from 0 to as high as 0.0182 ppm. Out of 9 samples, all samples have been found to contain Cu value < 0.05 ppm (Annexure V) which shows within desirable limit as BIS 2012 standard may be treated safe.

**Manganese**

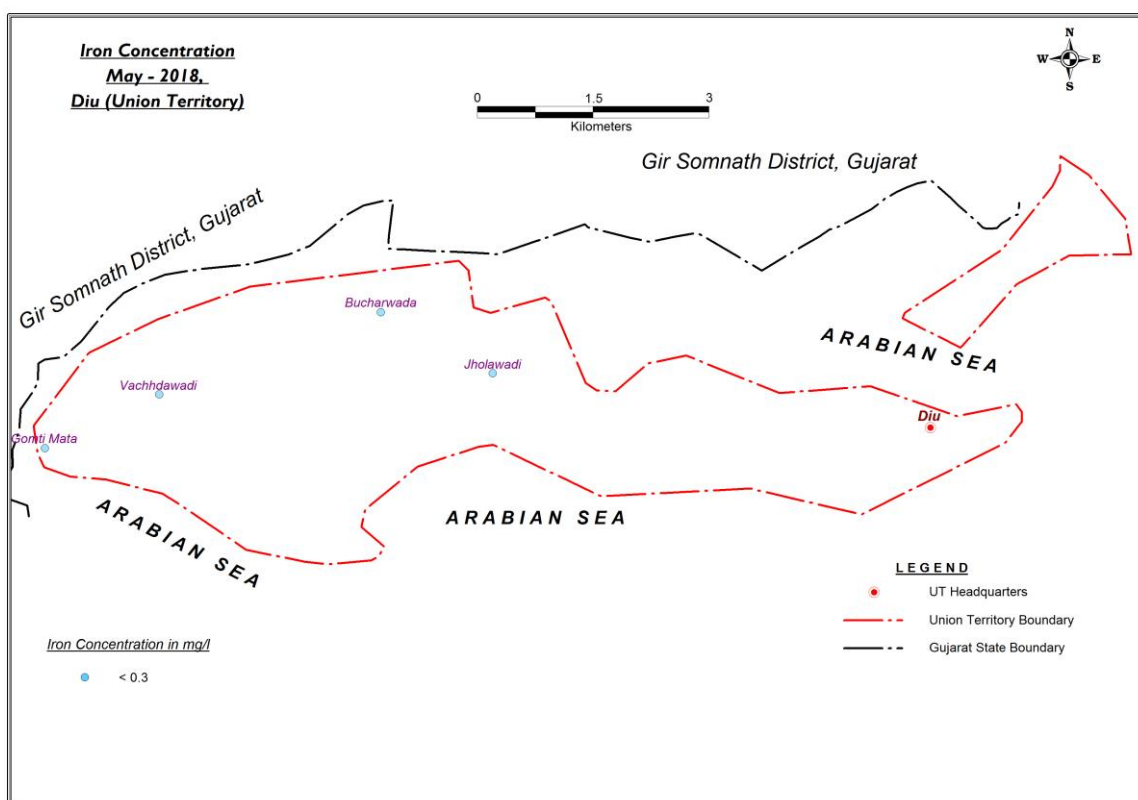
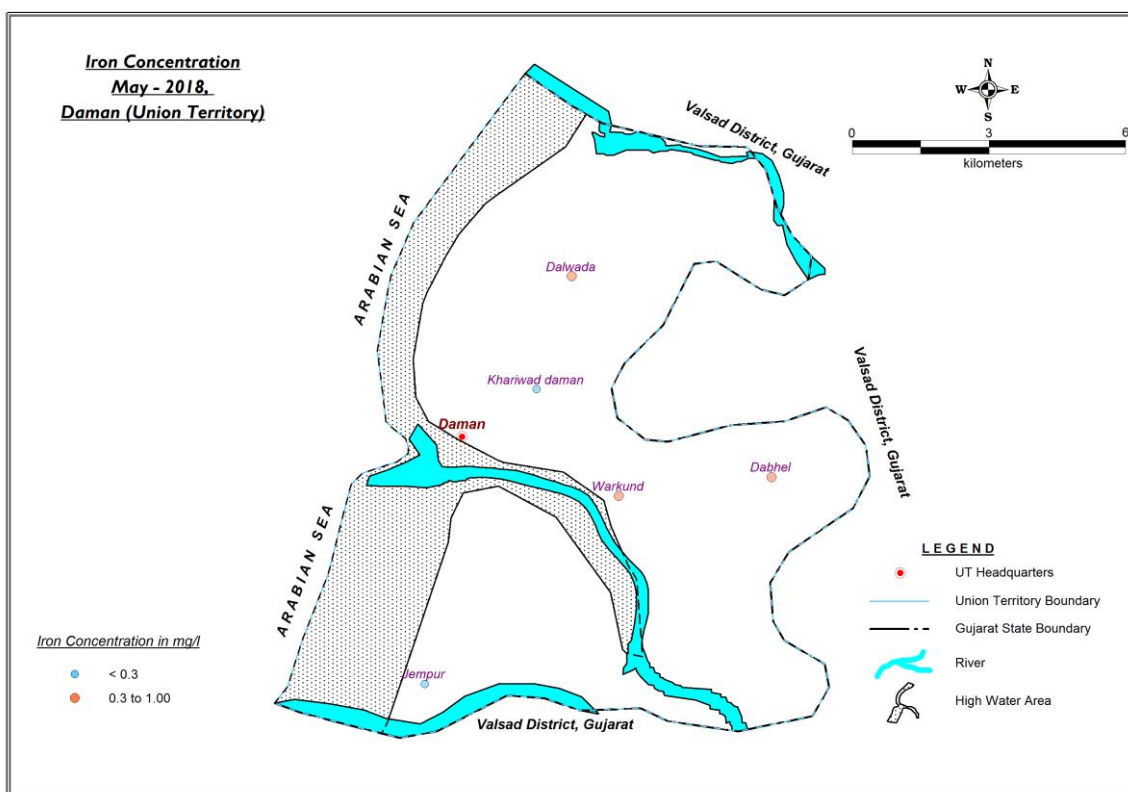
Manganese values ranges from 0.0114 to as high as 0.2680 ppm. Out of 9 samples, all samples have been found to contain Mn value < 0.3 ppm (Annexure V) which shows within desirable limit as BIS 2012 standard may be treated safe.

**Zinc**

Zinc values ranges from 0 to as high as 0.0851 ppm. Out of 9 samples, all samples have been found to contain Zn value less than 5 ppm (Annexure V) which is the desirable limit as BIS 2012 standard. Hence all the samples may be treated safe.

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Fig-15: Map of Iron concentration (May 2018) of UT of Daman and Diu



**WATER LEVELS OF THE NATIONAL HYDROGRAPH STATIONS IN UT OF DAMAN & DIU 2018-19 (PHREATIC)**

SI.No	District	Well Name	Latt_Y	Long_X	Well_Type	May_2018	Aug_2018	Nov_2018	Jan_2019
1	DAMAN	Ambawadi	20.403	72.844	DW	5.39	3.09	2.57	6.2
2	DAMAN	Bhimpor k.falia	20.458	72.871	DW				6.55
3	DAMAN	Dabhel	20.411	72.886	DW	6.08	1.39	1.12	6.3
4	DAMAN	Dalwada	20.443	72.852	DW	8.35	1.44	1.02	7.25
5	DAMAN	Daman	20.424	72.85	DW				
6	DAMAN	Jempore	20.378	72.827	DW	3.24	1.09	0.8	2.7
7	DAMAN	Khariwad daman	20.425	72.846	DW	7.13	1.62	1.31	4.13
8	DAMAN	Morwad	20.435	72.831	DW	11.8		2.02	6.6
9	DAMAN	Warkund	20.408	72.86	DW	6.16	0.74	0.55	5.1
10	DIU	Chakarteeth_Pz	20.708	70.969	Pz	6.42	6.04	6.02	6.28
11	DIU	Diu	20.715	70.949	DW				3.96
12	DIU	Gomtimata	20.708	70.876	DW	4.15	3.96	3.9	4.2
13	DIU	Jalawadi	20.722	70.933	DW			2.49	3.28
14	DIU	Pothia Bapa	20.702	70.912	DW	7.21	5.2	6.16	8.96

**Groundwater Table of Gujarat state during May 2018**

DISTRICT_NAME	SITE_NAME	Latt_Y	Long_X	May_2018	Elevation_GL	WT_May_18
DAMAN	Jempore	20.37777778	72.82694444	3.24	13.1	9.86
DAMAN	Ambawadi	20.40277778	72.84444444	5.39	14.1	8.71
DAMAN	Warkund	20.40805556	72.85972222	6.16	9.3	3.14
DAMAN	Dabhel	20.41111111	72.88611111	6.08	16.6	10.52
DAMAN	Khariwad daman	20.425	72.84583333	7.13	14	6.87
DAMAN	Morwad	20.43527778	72.83111111	11.8	19	7.2
DAMAN	Dalwada	20.44305556	72.85194444	8.35	22.4	14.05
DIU	Chakarteeth_Pz	20.70833333	70.96888889	6.42	7.3	0.88



**MEAN DECADAL WATER LEVELS OF THE NATIONAL HYDROGRAPH STATIONS IN UT OF DAMAN & DIU (PHERATIC) 2009-18**

DISTRICT	LOCATION	LAT_Y	LONG_X	PRE_MONSOON	POST_MONSOON
DAMAN	Ambawadi	20.4028	72.8444	5.65	3.55
DAMAN	Bhimpor k.falia	20.4583	72.8708	7.71	4.61
DAMAN	Dabhel	20.4111	72.8861	4.36	2.43
DAMAN	Dalwada	20.4431	72.8519	7.82	2.14
DAMAN	Daman	20.4242	72.8503	8.64	2.92
DAMAN	Jempore	20.3778	72.8269	3.52	1.61
DAMAN	Khariwad daman	20.4250	72.8458	4.49	2.48
DAMAN	Morwad	20.4353	72.8311	8.59	4.70
DAMAN	Warkund	20.4081	72.8597	6.29	2.16
DIU	Chakarteeth_Pz	20.7083	70.9689	6.31	6.16
DIU	Diu	20.7147	70.9486	3.80	

## WATER QUALITY DATA OF NATIONAL HYDROGRAPH NETWORK STATIONS IN UT OF DAMAN &amp; DIU MAY 2018

Well No.	District	Taluka	Location	pH	EC	TDS	CO3	HCO3	Cl	NO3	SO4	F	Alk	Ca	Mg	TH	Na	K
W202440072531001	Daman	Daman	Dabhel	7.84	738	494	0	159	114	8	89	0.37	130	52	36	280	52	0.7
W202635072510701	Daman	Daman	Dalwada	7.96	486	326	0	171	50	5	71	0.25	140	32	27	190	46	1.9
W202240072493701	Daman	Daman	Jempur	8.08	633	424	0	220	50	21	71	0.25	180	20	44	230	52	19.6
W202530072504501	Daman	Daman	Khariwad daman	8.44	858	575	24	232	99	3	11	1.00	230	24	32	190	91	13.5
W202429072513501	Daman	Daman	Warkund	8.03	1182	792	0	171	256	13	54	1.00	140	56	68	430	67	0.8
W204230070523501	Diu	DIU	Gomti Mata	8.27	3951	2647	0	549	816	130	250	0.58	450	96	129	770	520	48
W204318070555901	Diu	DIU	Jholawadi	7.5	34500	23115	0	183	4964	9	9500	0.39	150	780	2225	11100	2705	65
W204344070550801	Diu	DIU	Bucharwada	7.76	22800	15276	0	1171	4808	44	3482	1.04	960	380	547	3200	3735	83
W204309070532701	Diu	DIU	Vachhdawadi	7.96	15720	10532	0	281	5142	9	384	0.72	230	560	535	3600	1890	130
Max				8.44	34500	23115	24	1171	5142	130	9500	1.04	960	780	2225	11100	3735	130
Min				7.5	486	325.62	0	159	50	3	10.73534	0.25	130	20	27	190	46	0.7
Avg				7.98	8985.33	6020.17	2.67	348.56	1811.00	26.89	1545.71	0.62	290	222.2	404.78	2221.11	1017.56	40.28

**HEAVY METAL WATER QUALITY DATA OF NATIONAL HYDROGRAPH NETWORK STATIONS OF UT OF DAMAN & DIU MAY  
2018**

in ppm

S.No	District	Taluka	Location	Date of Collection	Cr ppm	Fe ppm	Mn ppm	Zn ppm	Cu ppm
1	Daman	Daman	Dabhel	Not Given	0.0045	0.4521	0.2358	0.0593	0.0000
2	Daman	Daman	Dalwada	Not Given	0.0000	0.4752	0.0303	0.0097	0.0000
3	Daman	Daman	Jempur	Not Given	0.0000	0.2360	0.0114	0.0851	0.0000
4	Daman	Daman	Khariwad Daman	Not Given	0.0000	0.0096	0.0143	0.0000	0.0000
5	Daman	Daman	Warku	Not Given	0.0051	0.3056	0.0270	0.0303	0.0000
6	Diu	Diu	Jholawadi	03-06-2018	0.0491	0.1452	0.1255	0.0378	0.015
7	Diu	Diu	Bucharwada	03-06-2018	0.0175	0.1377	0.091	0.0271	0.0182
8	Diu	Diu	Vachhdawadi	03-06-2018	0	0.1334	0.268	0.0248	0.0129
9	Diu	Diu	Gomti Mata	03-06-2018	0.0161	0.0709	0.0285	0.0181	0.0064

