केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

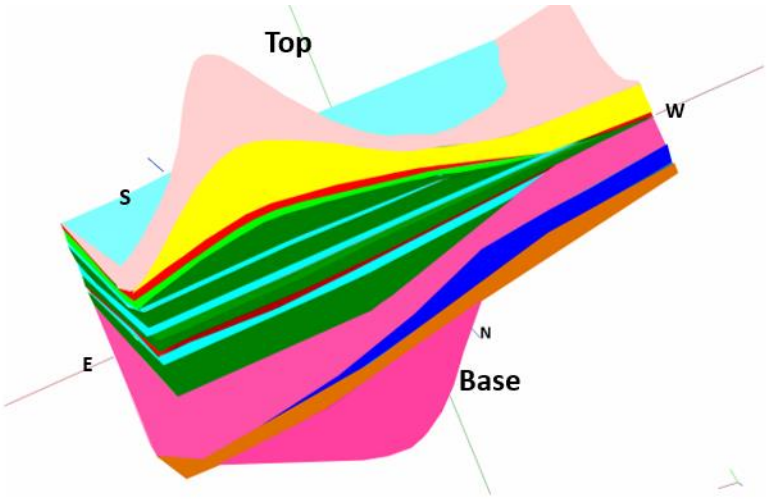
RAISEN DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

Central Ground Water Board
Department of Water Resources, River Development & Ganga Rejuvenation
Ministry of Jal Shakti
Government of India

Aquifer Mapping and Ground Water Management Plan of Raisen District, Madhya Pradesh



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2020-201

PREFACE

National Project on Aquifer Mapping (NAQUIM) is intended in knowing, understanding and managing the aquifers for sustainable development of groundwater which is the most important part for ensuring water security in India. The study involves a scientific process, where in a combination of geological, geophysical, hydrological and chemical analyses are applied to characterize the quantity, quality and sustainability of groundwater in aquifers. The result of these studies will contribute significantly to the resource management tools such as long-term aquifer monitoring networks, conceptual and quantitative regional groundwater flow models which can be used by planners, policy makers and other stakeholders for sustainable development of groundwater.

Under the National Project on Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Raisen district to prepare the aquifer maps of entire district in 1:50000 scale and formulate the block wise aquifer management plan. Geographical area of Raisen district is 8466.4sq.km out of which recharge worthy area is 6609.4sq.km. The district is mainly occupied by Deccan Trap Basalt, rock formations of Vindhyan Super Group and Archaean Granites in some portions. As per the Dynamic Ground Water Resources Assessment Report (2020), the annual Extractable Groundwater Resources in the district is 819.49mcm and the total groundwater extraction for all uses is 434.94mcm, resulting the stage of groundwater extraction 53.08%. Supply side management including augmentation of artificial recharge to groundwater is proposed in two blocks falling under semi critical category. Demand side management measures for sustainable development of groundwater is proposed in the remaining blocks in the district would enhance the agricultural productivity and economy of the district.

I would like to place on record, my appreciation of the efforts of **Mrs. Anakha Ajai, Scientist-B** for preparing the aquifer maps and management plan of Mandla district and compiling this report. I fondly hope that this report will serve as a valuable guide for sustainable development of groundwater in Mandla district, Madhya Pradesh.

Rana Chatterjee
Regional Director

Contents

List of tables

List of figures

ANNEXURES

Annexure I	Litholog of Exploratory Wells in Raisen District
Annexure II	Chemical Quality of ground water in Raisen district
Annexure III	Details of Exploratory wells in Raisen district
Annexure IV	Post monsoon Water Level Data, Raisen 2021
Annexure V	Post monsoon Water Level Data, Raisen 2021
Annexure VI	Water Level Fluctuation Data, Raisen 2021
Annexure VII	Location of Proposed Artificial Recharge structure Raisen

CHAPTER 1

INTRODUCTION

1.1 Introduction

Project on National Aquifer Mapping (NAQUIM) aims the mapping of aquifers, estimation of available groundwater resources and preparation of proper management plan for sustainable development and utilization of groundwater. Groundwater has very much importance in an agriculture-based country like India. Major share of agriculture in India depends on groundwater irrigation. Over the years, dependency of agriculture and major developmental activities on groundwater has adversely affected the groundwater levels in many parts of the country. As a part of NAQUIM project, information regarding groundwater available in different hydro-geological settings is collected through a process of systematic data collection, compilation, data generation and analyzed to prepare a suitable Aquifer Mapping and Management Plan for different parts of the country.

1.2 Objectives and scope of the study

The activities under NAQUIM are aimed at various aspects including identification of the aquifer geometry, aquifer characteristics and their yield potential, analyzing and inferring chemical quality of water occurring at various depths, aquifer wise assessment of ground water resources, preparation of aquifer maps and formulating ground water management plan. The two major objectives of the aquifer mapping is the delineation of lateral and vertical disposition of aquifers and their characterization on 1: 50,000scale in general and further detailing up to 1: 10,000 scale in identified priority areas and the quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders

Raisen district being spread over an area of 8466 sq.km with a recharge worthy area of 6609 sq.km have been entirely covered during the Annual Action Plan of 2020-21.

1.3 Approach and Methodology

The aquifer mapping study in this report has been compiled on the basis of existing data that were assembled, analyzed and interpreted from available sources. The collected data was further prepared to generate regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3-D aquifer dispositions and potentiometric maps eventually to define the aquifer geometry, type of aquifers, ground water regime behavior, hydraulic characteristics and geochemistry of multi-layered aquifer systems on 1:50000 scale. To achieve the objectives the following approach and methods have been adopted and stepwise details have been shown in the figure no. 1.

1.4 Study Area

Raisen district is situated towards the Southeastern part of Madhya Pradesh and bounded by Vidisha and Sagar districts in the North, East and Northeast Respectively. Bhopal, Sehore, Hosangabad and Narsinghpur districts bounds Raisen respectively in the West, the Southwest and the South. The area falls in survey of India toposheet No.s 55 E, F, J and I. Coordinates of the area are north latitudes 22º 47′ and 23° 33′, east longitude 77°21′ and 78° 49′ . The District is drained mainly Betwa and Narmada rivers.

Raisen, the district head quarter formed in 1950 is located on National highway No. 12, 86 A, and 34 towards Jabalpur, Sagar and Vidisha respectively. The study area is well connected to the surrounding districts by a good network of roads and railways. Important towns like Raisen,

Snachi, Obedullaganj and and Gairatganj are connected by roads. All the villages in the study area are connected to this basic frame work by a secondary network of roads. Raisen does not have any main railway stations. The district head quarter is 47 kms away from state capital Bhopal. The nearest airport is located at Bhopal 55km away from Raisen.

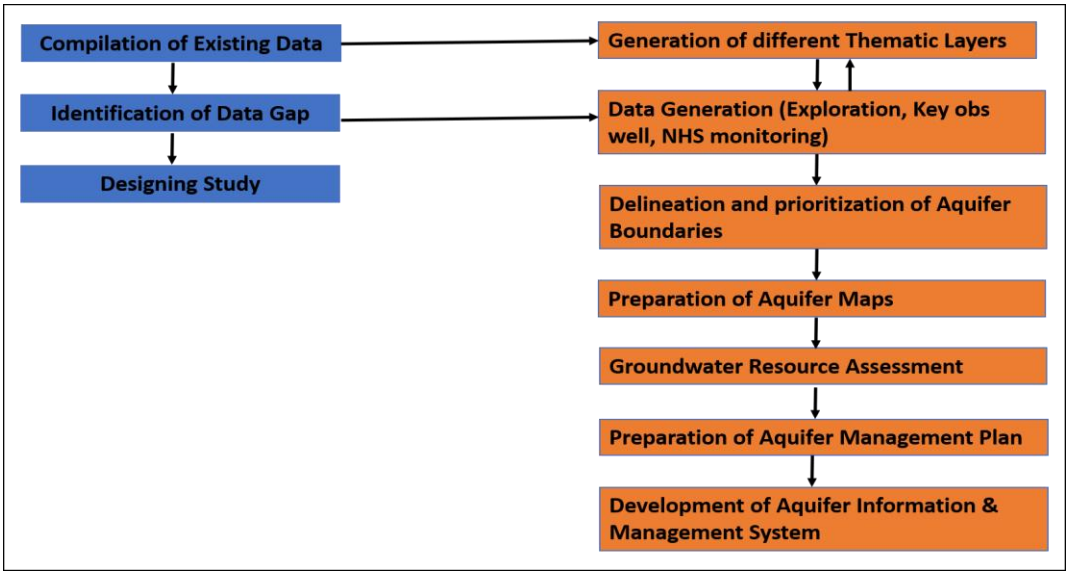


Figure No 1: Aquifer mapping approach and methodology

The total population of the district as per 2011 census is 1331597. The area of the district is 8466 sq km and it has been divided into nine tehsil and seven blocks. There are 1503 villages. A detailed location (index) map of the study area is shown in the figure no. 2.

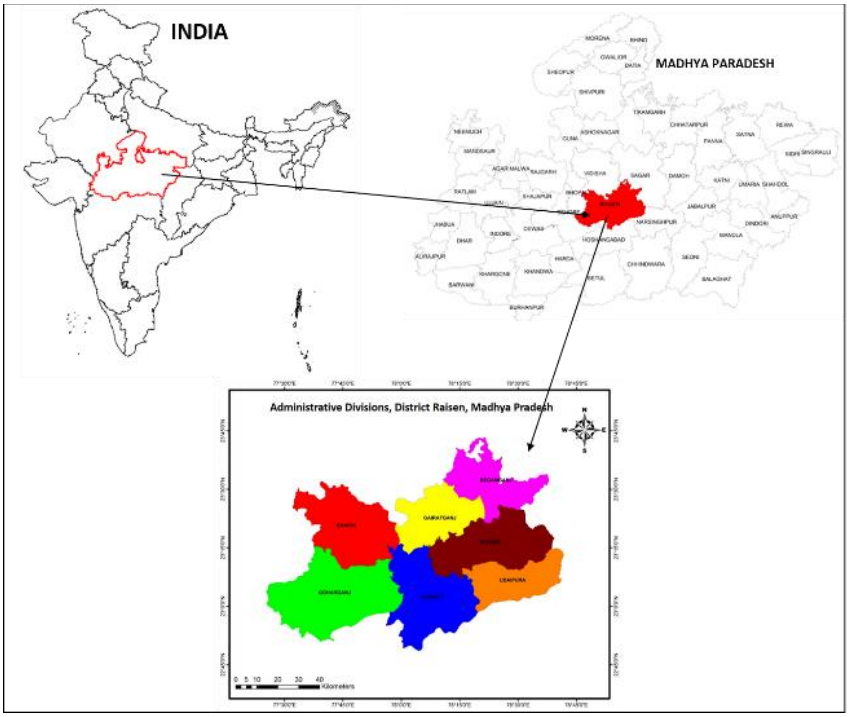


Figure No. 2: Location Map of Raisen district

1.5 Administrative Details

The Raisen district has been divided into 7 Blocks. There are 1503 villages in the district. Total population of the district is 1331597. Detailed administrative divisions of the district are given in Table-1.

Table 1: Administrative Divisions of Raisen district

Name of Assessment Unit (Block)	Recharge worthy area in Sq.Km	Areal extent (in Sq.Km)			
		Total Geographical Area	Hilly Area	Command Area	Non command
Badi	1418	1419	100	586	832
Begumganj	893	912	19	0	893
Gairatganj	746	920	174	0	746
Obedullagnaj	864.4	1749.4	885	0	864.4
Sanchi	1050	1360	310	0	1050
Silwani	996	1289	293	0	996
Udaipura	642	817	175	0	642
Dist.Total	6609.4	8466.4	1857	586	6023.4

As per the official census data 2011, the population of Raisen district is 1331,597 and population density is 160/km^2. Female population is 630781 and male population is 700798 and the population growth rate over past decade is 18.3%. Details are given in the table 2.

Table 2: Population details of Raisen district

Si.No.	Year	Population	±% p.a
1	1921	301,575	−0.61%
2	1931	296,365	−0.17%
3	1941	310,369	+0.46%
4	1951	315,358	+0.16%
5	1961	411,426	+2.69%
6	1971	553,026	+3.00%
7	1981	710,542	+2.54%
8	1991	876,461	+2.12%
9	2001	1,125,154	+2.53%
10	2011	1,331,597	+1.70%

1.6 Climate and Rainfall distribution

The climate of Raisen district, is characterized by hot summer and general dryness except during the south west monsoon season. The year may divide into four seasons. The cold season, December to February is followed by the hot season from March to about the middle of June. The period from the middle of June to September is the south west monsoon season. October and November form the post monsoon or transition period.

The normal annual rainfall of Raisen district is 1207.3 mm. The district receives maximum rainfall during south – west monsoon period i.e. June to September. About 92.2% of the annual rainfall received during monsoon season. Only 7.8% of the annual rainfall takes place between

October to May period. Thus surplus water for ground water recharge is available only during the south – west monsoon period. During 2020, Raisen received appr. 30% surplus rainfall of 1368.09 mm. Rainfall details of Raisen district is given in table 3.

Table 3: Annual rainfall of Raisen district of year 2014

Station (2014)	January	February	March	April	May	June	July	August	September	October	November	December	Total
Bareli	54	0	4	0	0	28	322	287	75	14	0	16	800
Begumganj	82	0	11	0	0	125	374	226	143	25	0	43	1029
Gairatganj	73	0	13	6	0	117	338	311	219	33	0	16	1126
Goharganj	28	0	0	0	0	12	582	138	213	0	0	3	976
Raisen	87	0	0	8	0	39	226	184	186	1	0	36	768
Silwani	44	0	3	0	0	82	309	301	268	0	0	11	1017
Udaipura	64	0	21	5	0	190	414	296	224	0	0	18	1232
Total	62	0	7	3	0	85	366	249	190	10	0	20	993

The normal maximum temperature received during the month of May is 41.5℃ and minimum during the month of January 6.8℃. The normal annual means maximum and minimum temperature of Raisen district is 32^0 C & 17.5^0C respectively. During the south- west monsoon season the relative humidity generally exceeds 87% (August month). The rest of the year is drier. The driest part of the year is the summer season, when relative humidity is less than 29%. April is the driest month of the year.

The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. The maximum wind velocity is 10.8 km / hr. observed during the month of June and minimum 2.2 km/hr during the month of November. The average normal annual wind velocity of Raisen district is 5.9 km / hr.

1.7 Geomorphology of Raisen district

1.7.1 Landforms

Structural hills of Vindhyan ranges, denudation hills of Deccan traps are predominant in Raisen district. Apart from these above geomorphic features like flood plain, alluvial plain, valley fills, intermountain depressions, pediment (Volcanic) are also sees in the district.

1.7.2 The Vindhaychal Range

The Vindhyachal range is composed of two parts, the trap hills and the vindhyan sandstone hills. Among the trap hills, those situated towards the west of Jhamar in Ghari area is 775.4 m amsl and hills situated to the NE of Siarmau have an altitude of 626.8 m amsl. The average elevation ranges between 530 m to 610m amsl.

In the western part of the district, the hills enclosing the narrow valleys of Jamner, Barna, Chiklod Kalanand the Palakmati extends in East-West direction. Tis range is parallel to the main Vindhyan range in the North of it. These ranges also form the water divide of Narmada and Ganga Basin. In the northwester part of the district, the Bhopal-Risen Road has hilly area on both sides of Betwa Valley. The maximum elevation is 574.1m amsl in this area.

1.7.3 Malwa Plateau

The plateau lies towards the north of the main line of Vindhyan hills. Altitude of the plateau ranges from 400 to 460 m amsl in Goharganj and Raisen tehsils and about 520m amsl in

Gairatganj and Begumganj plateau. The plateau is cut up at several places by outlying ranges and spurs of the Vindhyan. The lower plains are situated towards the East in Goharganj and Northwest Bareli tehsil at an altitude of 360m amsl.

1.7.4 Narmada Valley

The Narmada valley Les towards South of the main Vindhyan range covering the Udaipura and Southern half of Bareli tehsil at an average altitude of 300m to 360m amsl slopping towards south. Geomorphology map of Raisen district is given in figure no.3.

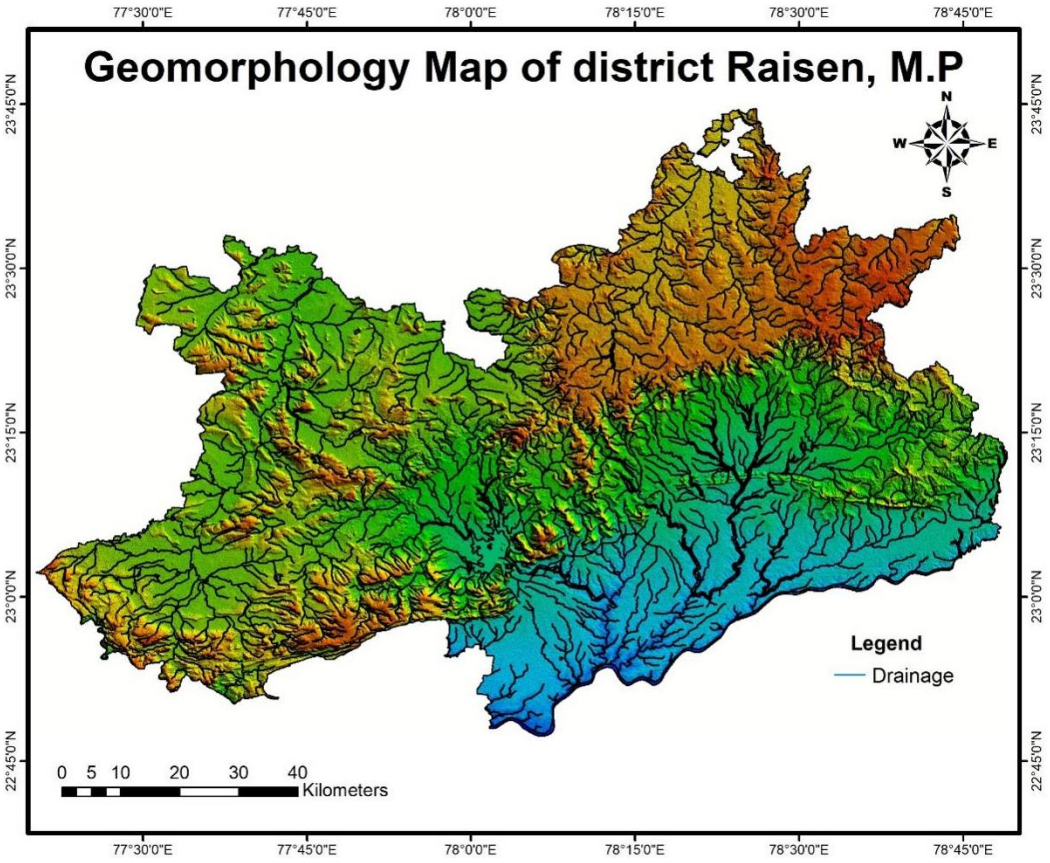


Figure No.3: Geomorphology Map of Raisen district

1.7.5 Digital Elevation Model

Based on the DEM SRTM data of Raisen district from USGS website, a digital elevation model is prepared for Raisen district. Base on the DEM, elevation in Raisen district ranges between 730m – 290 mamsl 440m. Maximum elevation is at the Northeastern part of the district towards the Begumganj and Gairatganj blocks. Sothwestern parts of Goharganj block also has high elevation. Towrds the Southeastern parts of the district i.e. with a high relief of is Silwani and Udaipura blocks, minimum elevation is observed. The Digital Elevation Model (DEM) is shown in the figure no. 4.

1.8 Drainage in Raisen district

The district lies in the drainage basins of the Ganga and Narmada rivers. The NE-SW trending Vindhyan range forms major water divide in the district. The northern portion of the district is drained by the perennial Betwa and Bina rivers and their tributaries while the southern part of the district is drained by the southerly flowing Sindori, Tendani, and Barna rivers and their tributaries joining the Narmada River which carries a large volume of water throughout the

year and forms about half of the southern boundary of the district. Drainage map of Raisen district is given as figure no.5.

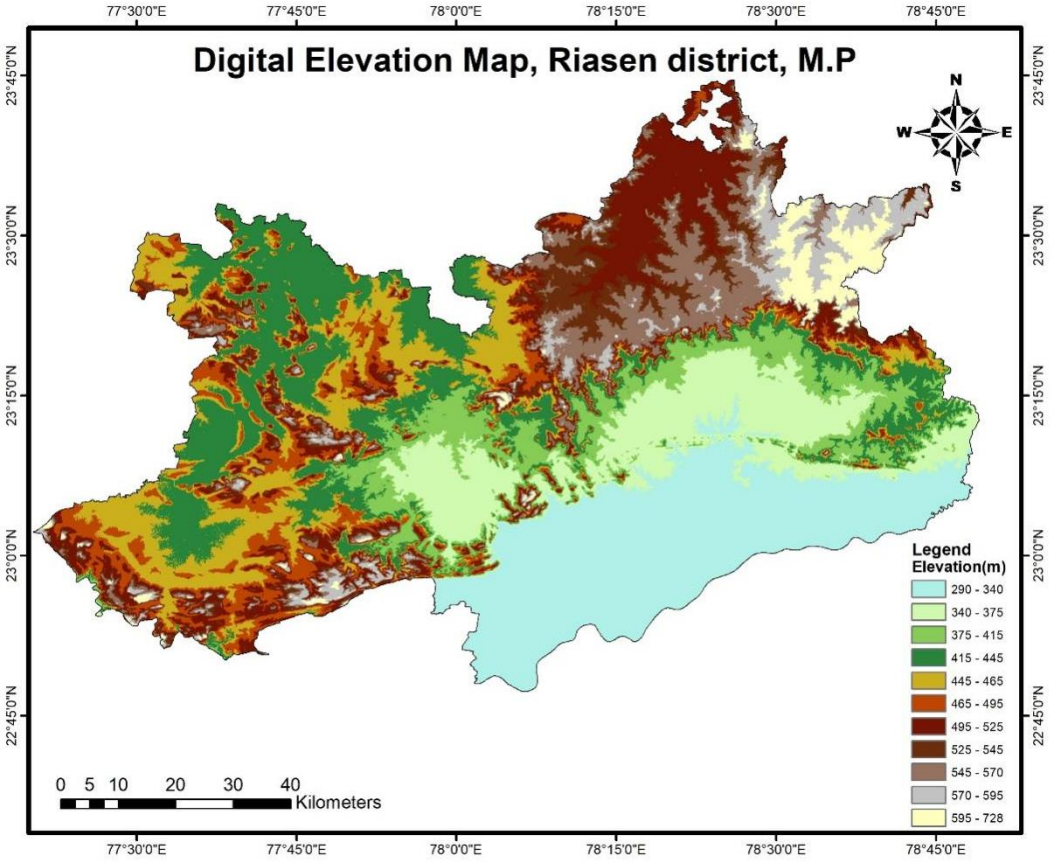


Figure No. 4: Digital Elevation Model of Raisen district

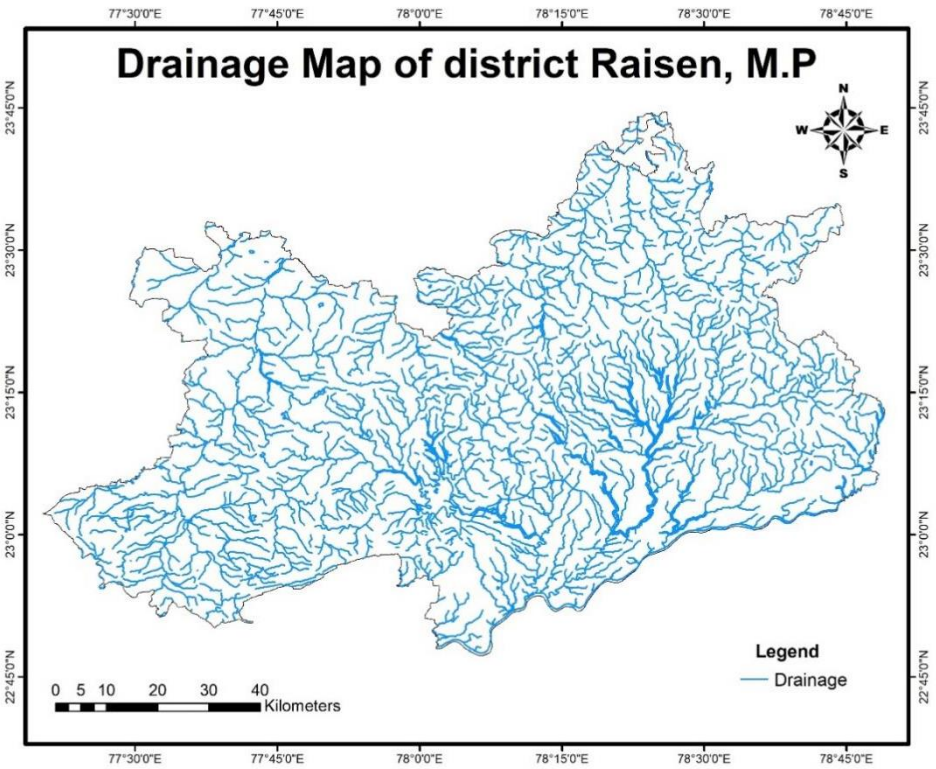


Figure No.5 Drainage Map of Raisen district

1.9 Land-use and cropping pattern in Raisen district

Raisen district comprises of 07 development blocks, 9 Tehsils, and 1503villages. Total geographical area of the district is 8466 sqkm, net sown area under agriculture is 5619 sq.km, forest area is 333.7 sq.km and 4445 sq.km is net cultivable area (figure no.6).

The total agricultural land available in Raisen district is 5619 sq.km. These are the lands primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. Net irrigated area of Raisen district is 1947 Sq.km and gross irrigated area is same the net irrigated area. 3127 sq.km is rainfed area. Details of sources of irrigation are given as table 4.

Table 4: Sources of irrigation in Raisen district

District	**Canals**	**Tanks**	**Tube Wells**	**Wells**	**Other Sources**
Raisen	565	7	254	686	435

Major crops cultivated in Raisen district includes Tur, soyabean, wheat, gram and lentil. Area under Kharif crops is 120. 7Sq.Km and area under Rabi crops is 380.4Sq.km. Details are given in table 5.

Table 5: Cropping details of Raisen district

Kharif			**Rabi**		
Area (sq.km)	Avg. Yield (kg/sq.km)	Production (tonnes)	Area (sq.km)	Avg. Yield (kg/sq.km)	Production (tonnes)
120.7	980	118.5	380.4	1218	463.3

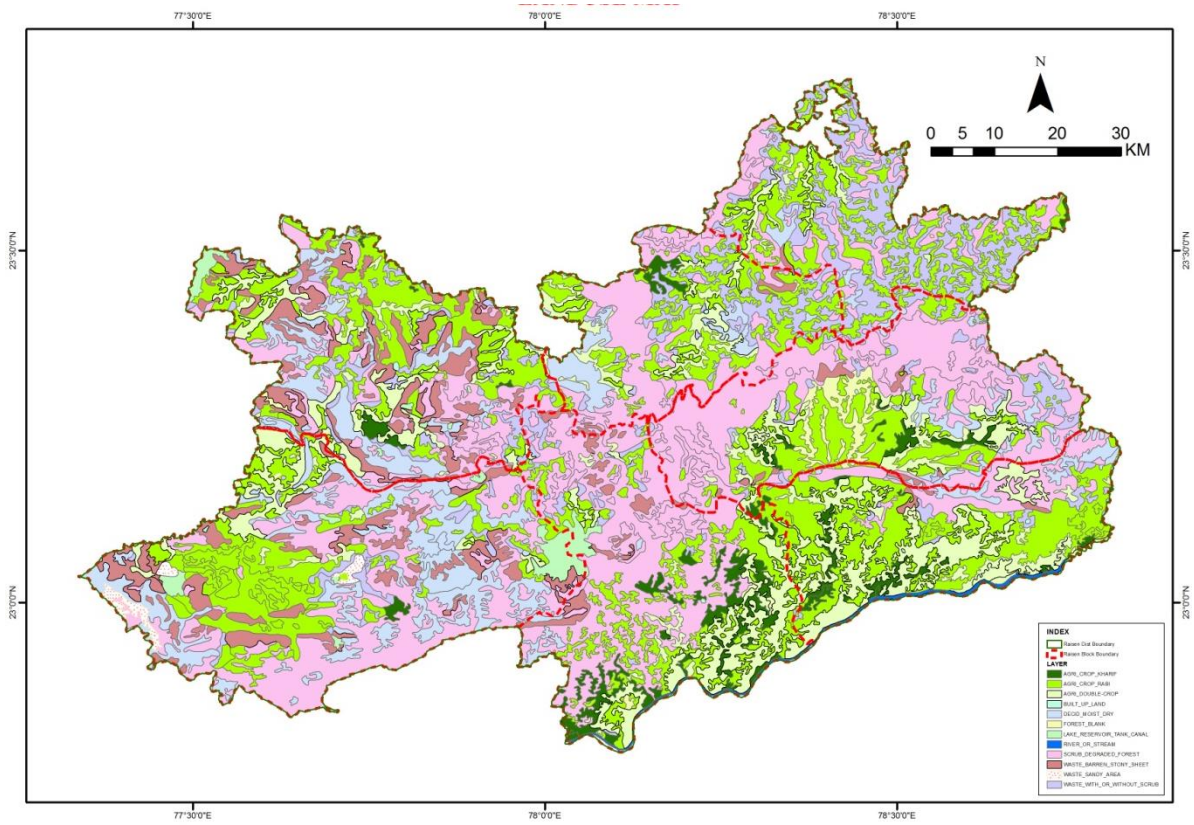


Figure No.6: Land use Map of Raisen district

1.10 Soil cover in Raisen district

The soils of the district are locally classed into six types depending upon their appearance and crop bearing. The superior Kalmat a loamy soil of black colour, when dry is become very hard and developed craks, but when wet it is soft and clayey. It remains moist for a considerable period. This soil is found on hillsides and in the areas occupied by the Deccan Lava flows. It is suited to wheat, masur and gram. Bhanwar is a gray-coloured soil, mixture of Kalmat and Soyar soils. It is loose textured retains moisture considerably. Soyar or Pitula is yellow or brownish colour, shallow in thickness, large to small pebbles and is found on the slop of hills. Siari is a poor soil of grey yellowish or reddish black colour. It is loose and sandy in constitution. If irrigated, it suits to grow rice. It is shallow and does not retain much moisture. Bharwa is a light, sandy shallow soil of black or brown color. It is found mostly on the foothills. It grows only the inferior crops. Kachar or Chap is an excellent loamy soil found in the banks and beds of streams. It grows fine crops of wheat, jawar and vegetable.

1.11 Geology of Raisen district

The geology of the area under study comprise, Vindhyans Super Group, Deccan traps Laterites and Alluvium the sequence of the geological formation obtained in the area is given in table 6.

Table 6: Geological Succession of Raisen district

Name of formation	Lithology	Period
Alluvium	Sand and clay	Recent
Laterlis	Laterites	Pleistocene
Deccan Traps	Basaltic lava flows	Cretaceous to Eocone
Lametas	Limestone chert, flints caly	Cretaceous

Upper Vindhyan	**Bhander Saries –** Shales sandstone & Limestone **Rewa Saries –** upper Rewa Sandstone	Precambrian

1.11.1 Rewa Series: The upper Rewa sandstone is a hard, cause-grained, reddish dark in colour, compact a quite resistant to weathering and of frequently breaks along the joints into large cubical blocks, it presents a mixture of massive strata. The thickness of the sandstone varies from place to place. To the north of the Sonar River the upper Rewa sandstone outcrops in the form of northwestern scarp land. The thickness of this formation is between 90 and 120 meters above to level of Surrounding areas.

1.11.2 Bhander Shales: Bhander limestone:
The Bhander limestone is a variable rock of the series. The thickness of limestone varies considerably as carbonate of lime disseminates amongst the calcareous shales associated with limestone and partly taking its place. The limestone, is generally earthly and compact light yellow of dark grey in colour.

1.11.3 Lower Bhander Sandstone:
The general characteristics of lower Bhander sandstone are Thin-bedding, some parts being pitted with numerous red clays. Red and sometimes dirty grey white are the general colours.

1.11.4 Sirbu shales:
The Sirbu shales resting on the lower Bhander sandstone are well exposed all-round the precipitous scarps of the Bhander sandstone, The characteristic feature of the Sirbu shales is their red colour through sometimes it is greenish grey, thinly bedded, soft and can be broken by level. The general characteristics of the Sirbu shales are uniform throughout their exposures. A large number of gullies have developed due to others of the shales. The thickness of the Sirbu shales varies from 30 to 60 meters.

1.11.5 Lametas:
The lameta beds consist of cherty or silicones limestone, flints clays of shales of fresh water origin. The limestone usually occurs as irregular blocks of varying thickness. It is generally soft and can be easily broken by hammer. Lameta series in the Sonar-Bearma basin rests conformably on the upper Bhander sandstone. The lemetas series are lying horizontal and no disturbance has been noticed in area.

1.11.6 Deccan traps:
Deccan trap shows a remarkable uniformity in both chemical and mineral composition. The presence of the inter-trappean beds between the two successive flows indicates that there must have been a fairly long interval of time between successive eruptions. 6 flows been reported in the area. The thickness of the flow varies from 12 to 33.5 meters.

1.11.7 Laterites:
Laterite is ferruginous residual rock, generally it occurs as a sub aerial residual weathered product on the high hills or uplands. But it is generally noticed that all the better-known extensive occurrence of the laterite in the peninsula are capping on the basaltic lave flows of the Deccan traps. Laterites deposits are generally seen at the height of 610 meters and above The thickness of the laterite varies from a few centimeters to more than 30 meters.

1.11.8 Alluvium:

Alluvium or the hand forted soil is the Recent deposit which occupies the middle and lower part of the basin. This soil varies in depth and is usually loamy to clayey in texture. Most of the material along the Sonar valley is brought by the sonar and its tributaries in the belt alluvium is so thick that the underlying formation, except in the river bed are not visible on the surface. This alluvium is loam to sandy loam and is characteristically different from the clayey soil of the Deccan trap region

CHAPTER 2
DATA COLLECTION AND DATA GENERATION

2.1 Data Collection and Compilation

Data for various components were collected and compiled for NAQUIM studies in Raisen district as discussed below.

Hydrogeological Data

- 10-year water level data along with trend of monitoring wells of CGWB viz. National Hydrograph Stations representing Aquifer-I (Shallow aquifer) are collected.
- The weathered zone thickness (aquifer-I), lithological details of deeper aquifers (aquifer- II) of exploratory wells were also collected and compiled.

Hydro chemical Data

- Ground water quality data shallow aquifer of NHS monitoring wells of CGWB are collected and compiled.
- Groundwater quality data from exploratory wells representing deeper aquifer are collected and compiled.

Exploratory Drilling

- Data of groundwater exploration carried out in Raisen district by CGWB are collected and compiled from previous reports.

Geophysical Data

- Data of geophysical exploration carried out in Raisen district by CGWB are collected and compiled from previous reports.

Hydro meteorological Data

- 5-year rainfall data for the whole district (block wise) from Indian meteorological Department and Water Resource Department are collected.

Statistical Data

- Data of prevailing cropping pattern from District Irrigation Plan, Raisen district.
- Data of existing surface water irrigation structures from District Irrigation Plan, Raisen district.
- Data of prevailing land use pattern, Raisen district from Dept. of Statistics, Economics and Planning, M.P.
- Demography data of Raisen district from Dept. of Statistics, Economics and Planning, M.P.

Remote Sensing Data

- DEM SRTM data of Raisen district from USGS website

2.2 Groundwater Exploration and Aquifer parameters

In many parts of the Raisen district, the Systematic Hydrogeological surveys were conducted during Indo-British Betwa groundwater project in 1975-1980. During this project study 4 exploratory boreholes were also drilled in the district. During 1959-61 Mr. A S M Rao has carried out systematic hydrogeological surveys in the southern fringe the district. Under the World Bank assisted Hydrology Project- I, 7 shallow and deep piezometers have been drilled

by the Central Ground Water for water level and quality monitoring. The salient details of the some of the drilled bore wells and piezometers are given in Annexure -3 and location of exploratory wells in Raisen district are given in figure no.7.

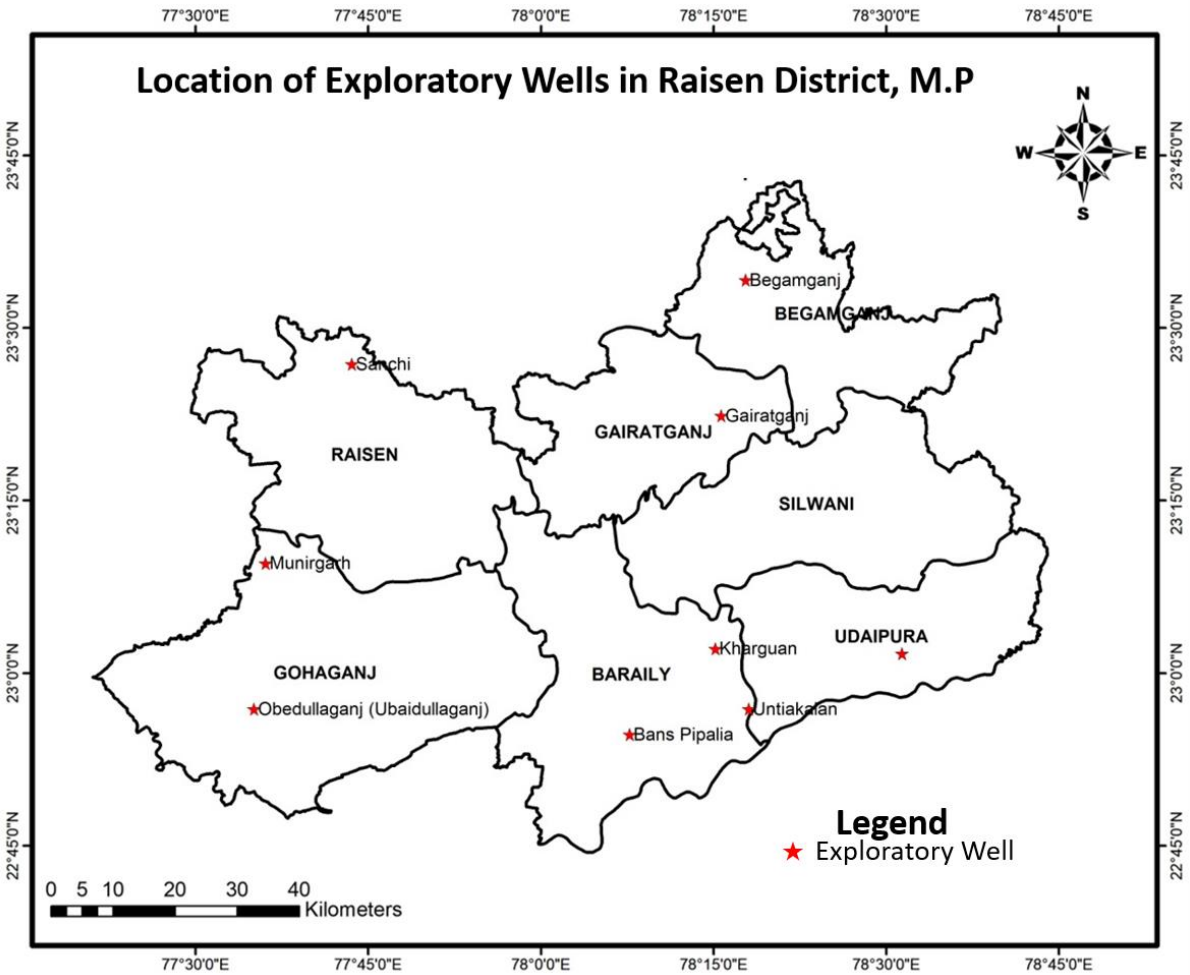


Figure No.7: Map showing location of exploratory wells in Raisen district

2.3 Hydro chemistry of Raisen district

The water samples were collected from National Hydrograph Stations in clean double stopper poly ethylene bottles from 24 different locations of Raisen district during May 2021. The samples were analyzed for 14 basic parameters at the chemical lab of CGWB, NCR, Bhopal. As the occurrence of groundwater is mainly in the basaltic aquifer, almost all the basic parameters fall under the permissible limits as per BIS standards except for Nitrate occurring in patches. Interpretation of chemical data is discussed in detail in coming chapters.

CHAPTER 3
DATA INTERPRETATION AND AQUIFER MAPPING

3.1 Occurrence of Groundwater

The water bearing and retaining properties, occurrence, movement, control and recharge of groundwater of different lithological units in Raisen district are described as below. Hydrogeology map of Raisen district is given as figure no.8.

3.1.1 Vindhyan

a) Upper Kaimur-

This group comprises of sandstone and conglomerate at the base and forms hilly areas and scarps. The sandstone possess less porosity and permeability as they are hard and compact. This group is not particularly a good aquifer.

b) Rewa Series-

These comprises of sandstone and Jhiri Shale which area exposed at the base of scarps forming ridges. The groundwater at shallow depth is confined to joints and weathered zones only.

c) Bhander Series-

Ganurarh Shales- The rocks possess low permeability The shales are susceptible towards weathering and give rise to a suitable weathered zone which yields limited quantity of groundwater at shallow depth under phreatic condition. Groundwater also occurs along the bedding planes.

Bhander Limestones-These are hard and compact but exhibit joints and fractures. They give rise to thick weathered zone upto 5m in topographic lows. There are chances of getting good yield in these rocks as solution cavities and joint planes acts as aquifer.

Bhander Sandstone- These sandstones are compact, fine to medium grained and highly jointed forming secondary porosity and permeability and yield limited quantity of groundwater.

3.1.2 Lametas

Occur in the form of small irregular patches above the Vindhyan rocks and does not have much significance as an aquifer.

3.1.3 Deccan Traps

The basaltic rocks are upper cretaceous to Eocene in age and occupy the central and eastern parts of the district filling in the valleys of pre-existed Vindhyan topography. Individual lava flows vary in thickness from 10 to 30m comprising of two distinct unts.

a) Upper vesicular/amygdaloidal basalt with weathered mantle.
b) Lower massive and compact basalt with fractures, joints and at places, columnar joints.

The vesicular basalt forms a good aquifer yielding considerable quantity of groundwater. The massive basalt when occupy the favourable geomorphic setup and if jointed and fractured forms moderately good aquifers due to the secondary porosity developed in them.

3.1.4 Alluvium

Alluvium in the area is mostly silty and clayey, fine to medium grained with admixture of clay and kankar. The thickness ranges between 8 to 25m and is found along the major river courses. Sandy or gravel zones which are worthy of groundwater occur near Obedullaganj. These alluvial pockets form the aquifer in the area.

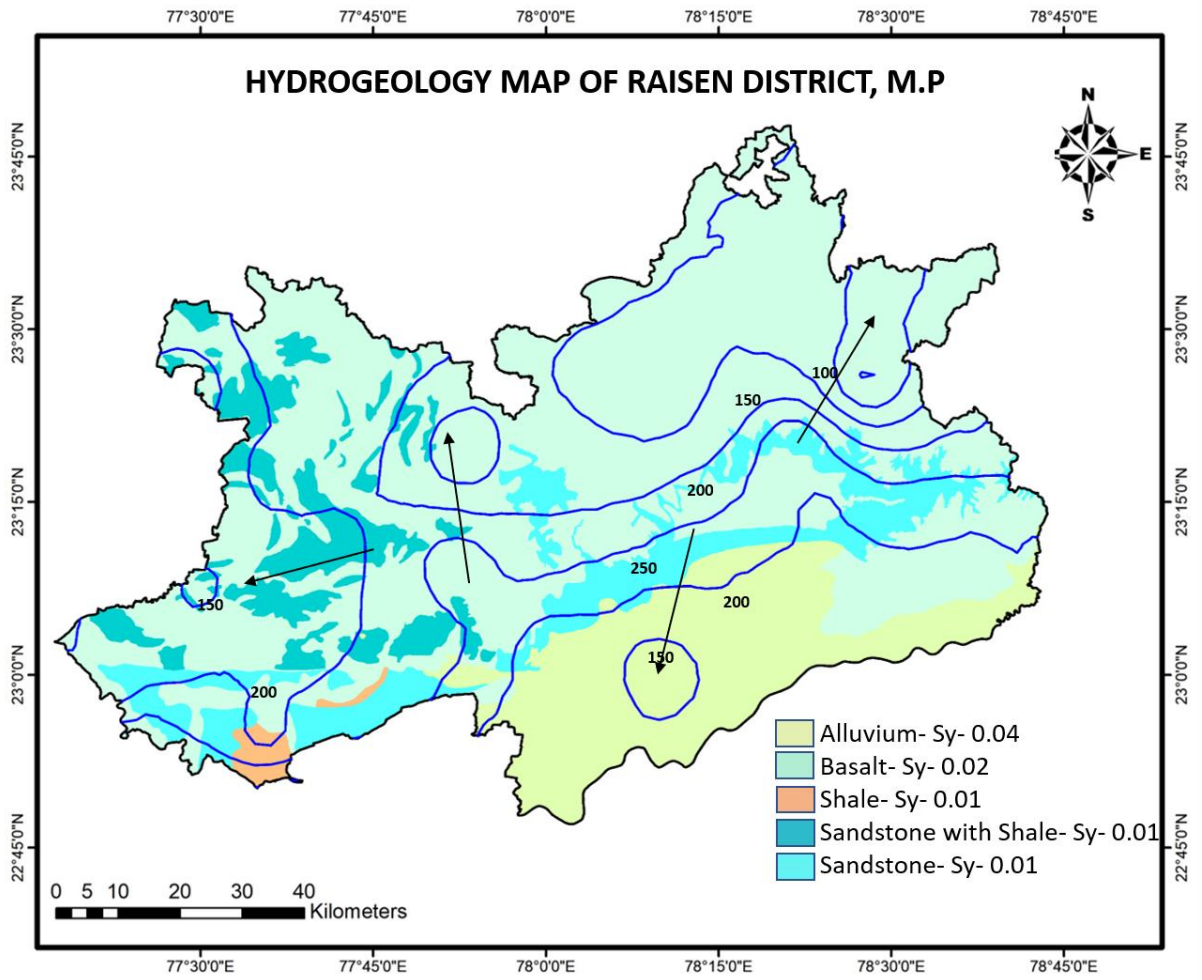


Figure No.8: Hydrogeology map of Raisen district

3.2 Analysis of Depth to Water levels in Raisen district

3.2.1 Pre-monsoon water level (May 2021)

The pre-monsoon depth to Water levels ranges from a minimum of 1.26 meters below ground level (mbgl) at Maindwada observation well in Obedullaganj block to a maximum of 14.9 m bgl at Uadipura observation well in Udaipura block of Raisen district. Very shallow water levels up to 3-6m bgl have been recorded in a 12 observation wells and central, West and Northwestern parts of district. About 45 % of monitoring wells recorded water level in the range of 3-6m bgl. Water Level between 6-9m bgl is observed in 3 observation wells and 9-12 m bgl in 9 observation wells towards the south, southwest, north and northeast parts of the district. Water level more than 12m bgl is observed in one well towards the southeast part of the district at Udaipura observation well. Depth to water level map of pre monsoon 2021 is given in figure no.9.

3.2.2 Post-monsoon water level (Nov 2021)

The post-monsoon depth to Water levels ranges from a minimum of 0.75 m below ground level at Raisen observation well in Sanchi block to a maximum of 10.9 m bgl at Dhangwan observation well in Silwani block of Raisen district. Very shallow water levels up to 3 m bgl have been recorded in 7 observation wells.

About 70% of monitoring wells recorded water level in the range of less than 3-6 mbgl category, covering the major portion of the district. Water Level ranging from 6-9m and more than 9m bgl are observed in a few observation wells. Depth to water level map of post monsoon 2021 is given in figure no.10.

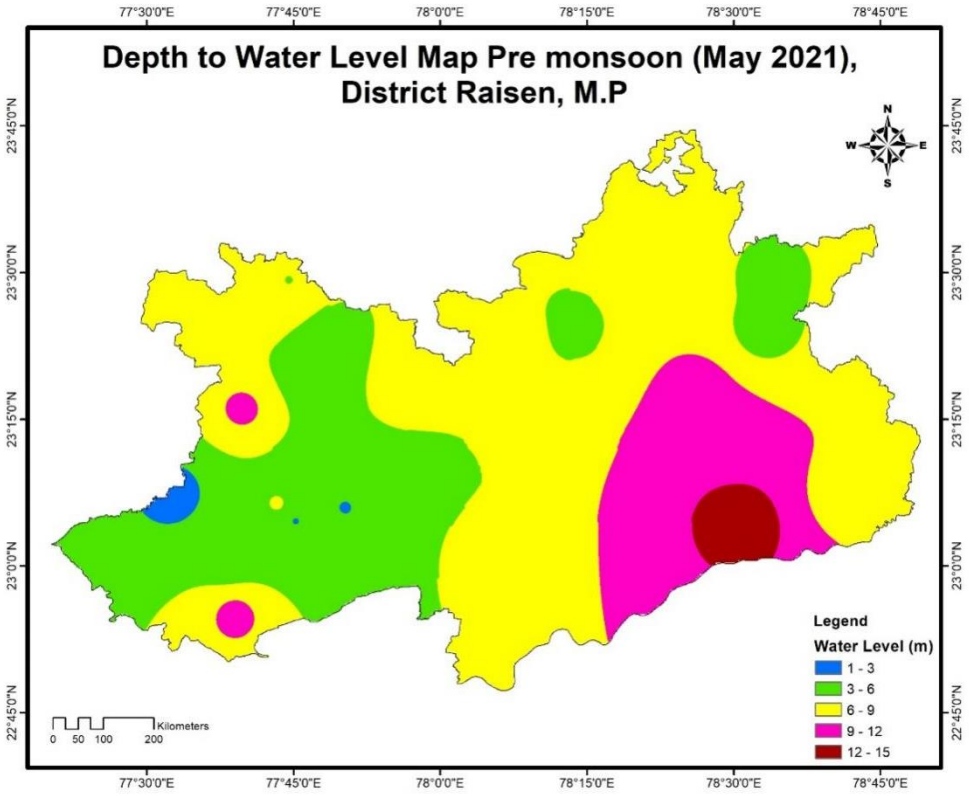


Figure No.9: Depth to Water Level Map, May 2021

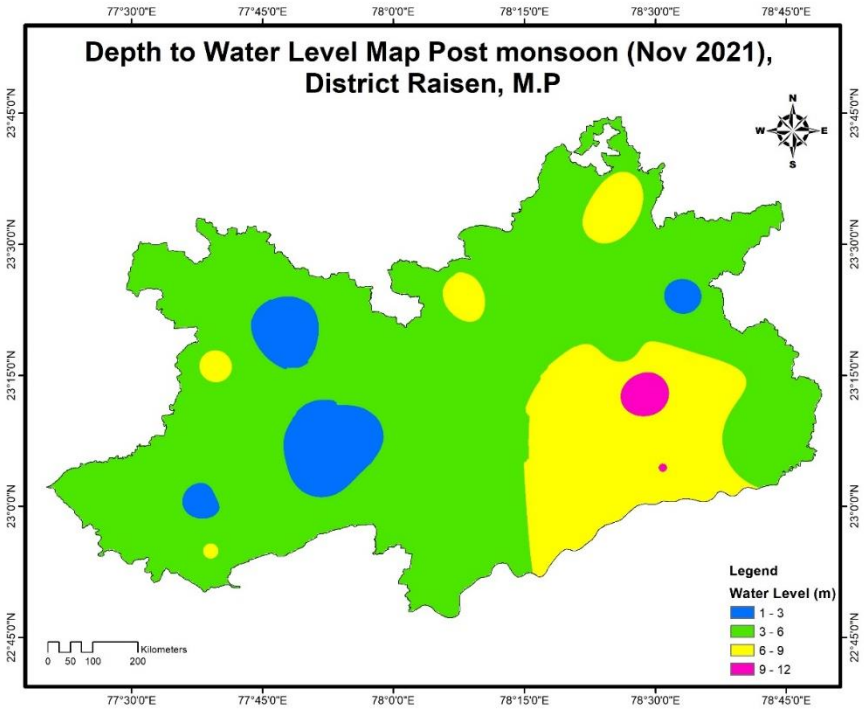


Figure No.10: Depth to Water Level Map, November 2021

3.2.3 Seasonal Water Level Fluctuation

The fluctuation between pre and post monsoon period water level for the year 2021 had calculated to determine the effect of rainfall on recharge (figure no.11). A general rise of water levels over the entire survey area is observed and average fluctuation of the area is 2.13 m. In 80% of the total study area the fluctuation range is 1 to 4 m. Maximum fluctuation is observed at Maindwa, water level fall by 3.84m and at Udaipura where water level is raised by 5.3m.

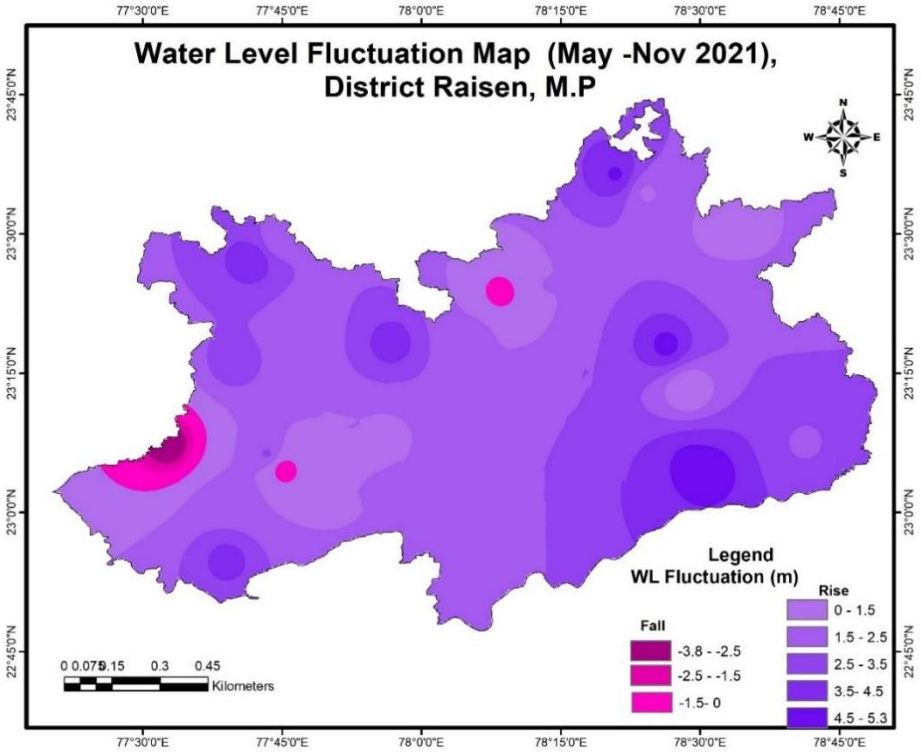


Figure No.11 Water Level Fluctuation Map, May-November 2021

3.2.4 Decadal Water Level Trend

The trend of the ground water levels of an area over a period of time reflects the behavior of ground water over time. In order to understand the long trend water level trend in Raisen district, decadal water level fluctuation map and hydrographs of Shajapur district were analyzed. The decadal water level trend maps (2011-21) (figure no. 12,13) shows both falling and rising trend in the district. The decadal water level trends indicates that pre monsoon water levels are showing rise in major part of the district and the post monsoon water levels are falling. This indicates that during and after post monsoon period, excessive pumping of groundwater is occurring in Raisen district which cannot be balanced by natural rainfall recharge. The rising trend may due to the surplus rainfall in the year 2019 and 2020.

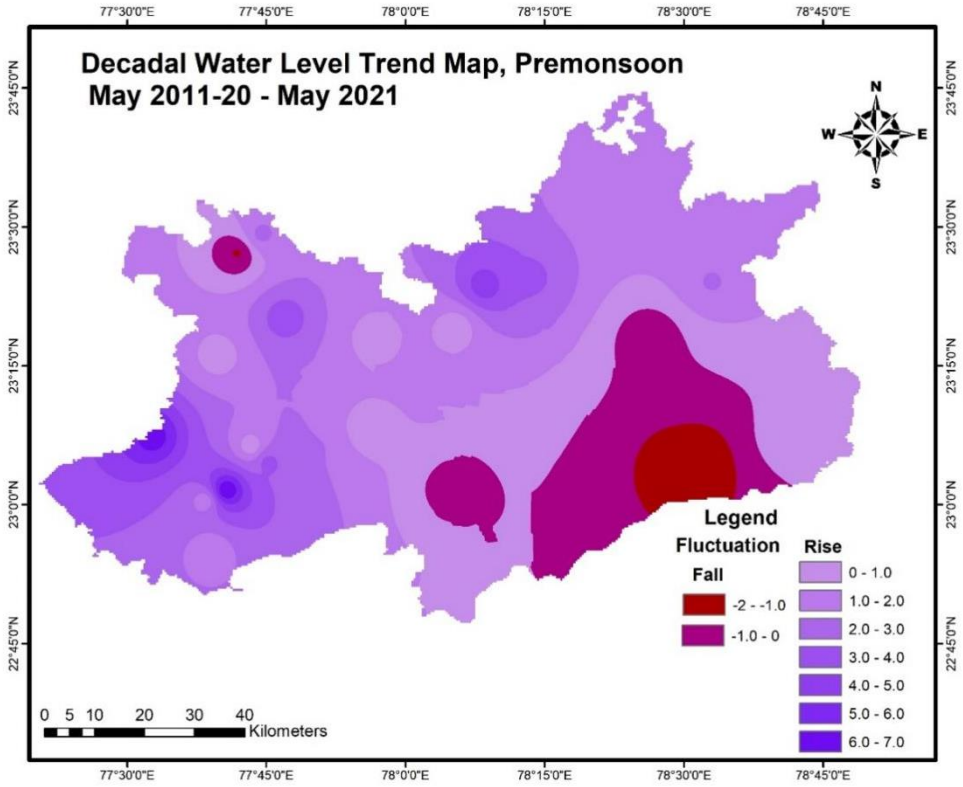


Figure No.12 Decadal Water Level Trend Map, May 2011-20- May 21

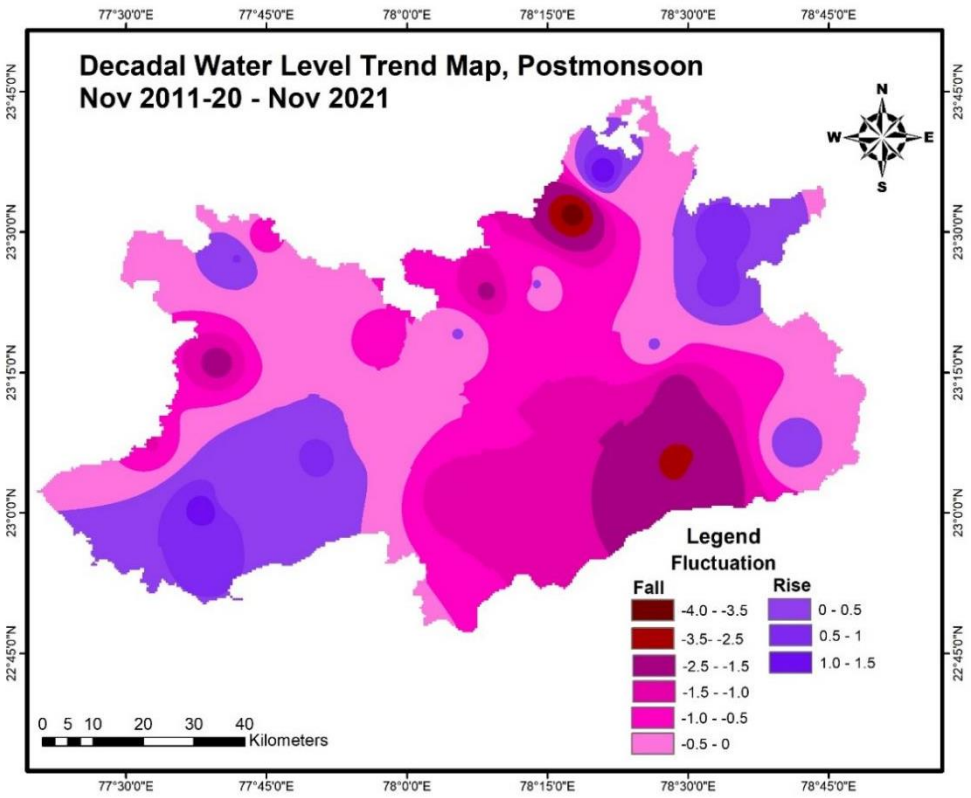


Figure No.13 Decadal Water Level Trend Map, Nov 2011-20- Nov 21

3.3 Data Interpretation, Integration and Aquifer Mapping

The lithological data collected from CGWB Borewells and Piezometers were studied, compiled and prepared 3-D model as well as 2-Dimensional Cross section. The sub-surface lithology of the Raisen district as inferred from the 2-D Section is presented in figure no.s 14,15 and 16.

3.3.1 Three-Dimensional Aquifer Model

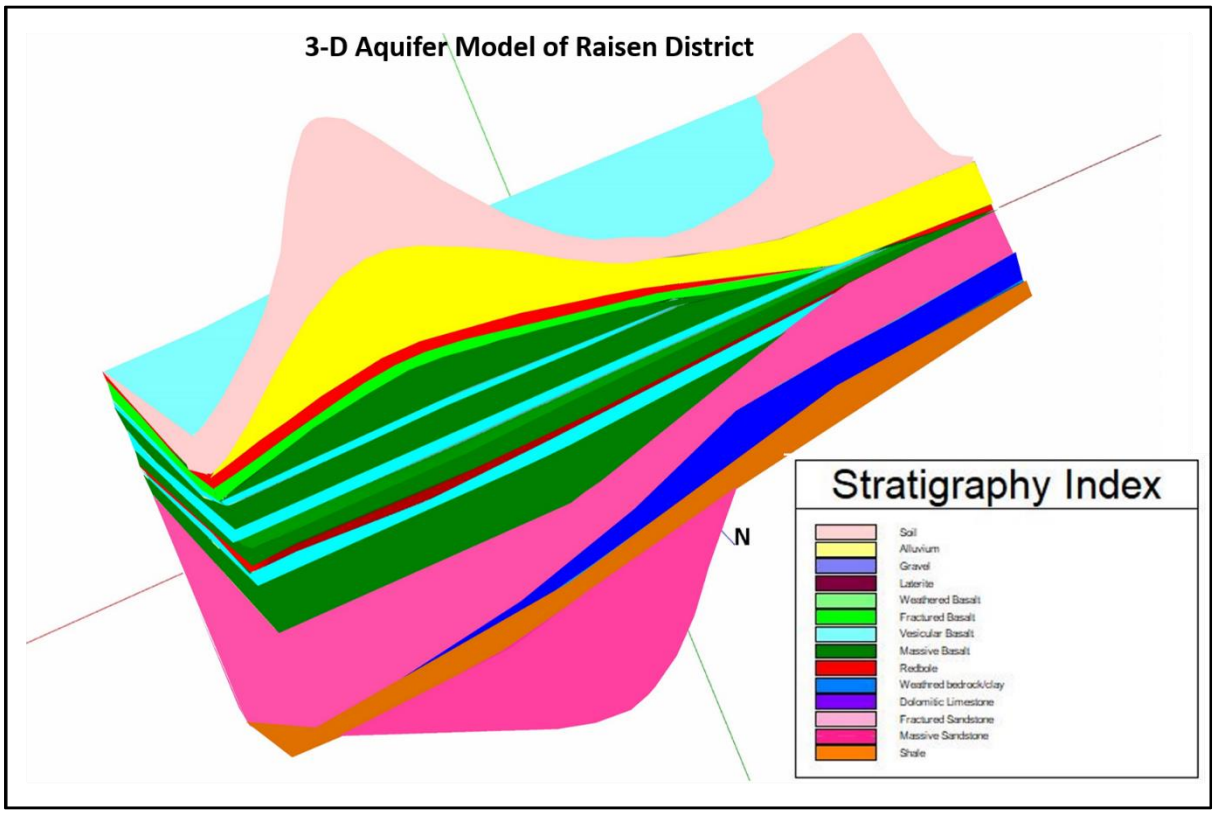


Figure No.14: 3-D Aquifer Model of Raisen District

3.3.2 Two-Dimensional Cross Section

2-Dimensional cross-section along the section line A-A' (N-S), covering the wells Sanchi, Munirgarh and Obedullagnj and B-B' (NE-SE) covering the wells of Begumganj, Gairatganj, Kharguan and Bans Pipalia have been prepared using Mapinfo. The cross-section shows that the shallow aquifer is not continuing for the whole region and occurs as narrow pinches in the Western portion of Raisen and is mainly of Basalt underlained by Vindhyan sandstone and Shale. The deeper aquifers whereas, occurs throughout the section line and can be encountered at depth where fractures are present. Towards the Silwani, Uadipura and Bareli blocks, alluvium forms the shallow aquifer followed by Deccan Basalt and Vindhyans as deep aquifers.

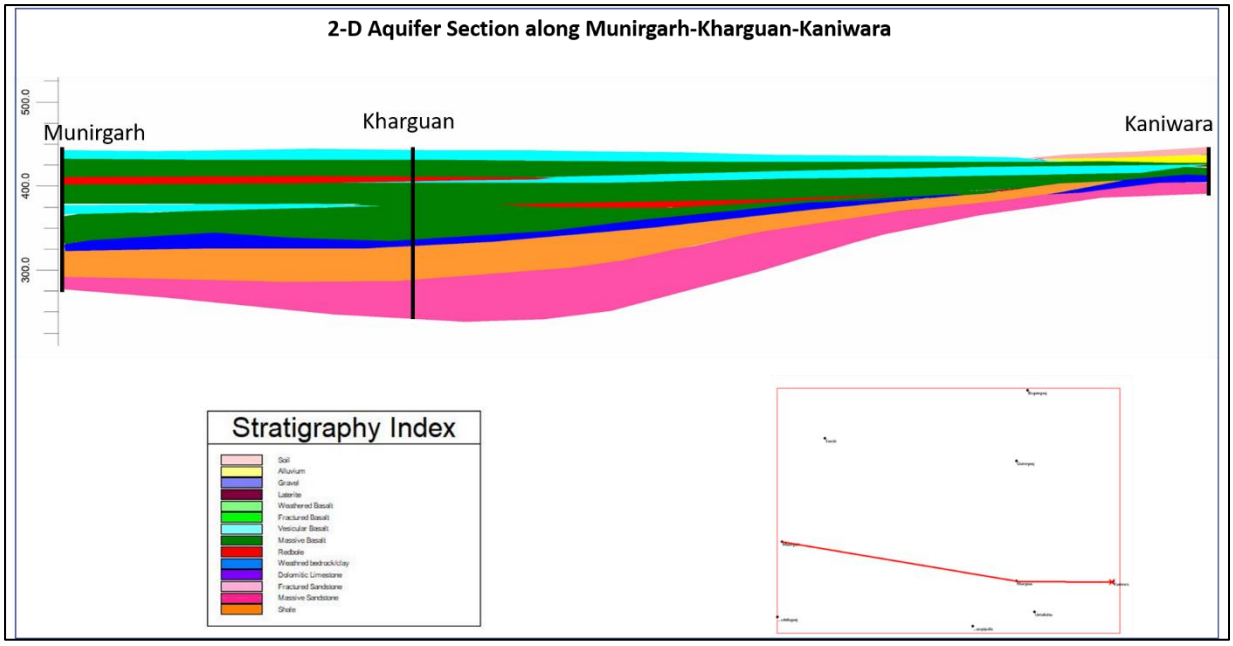


Figure No.15: 2-D Aquifer Section of Raisen District along Munirgarh-Kaniwara

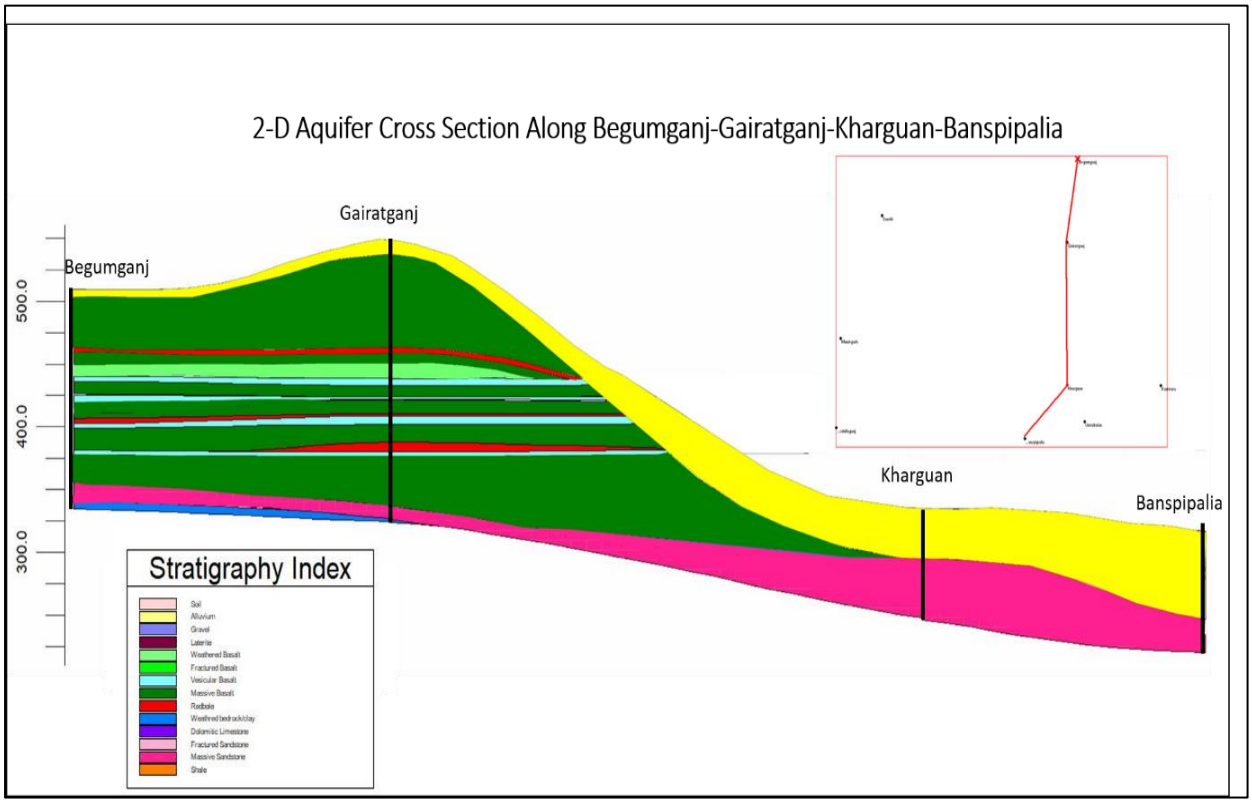


Figure No.16: 2-D Aquifer Section of Raisen District along Begumganj-Banspipalia

3.4 Hydro-chemical scenario of Raisen District

The water samples were collected from National Hydrograph Stations in clean double stopper poly ethylene bottles from 24 different locations of Raisen district during May 2021.

3.4.1 Quality of Ground Water for Drinking Purpose:

The ground water samples from Raisen district have varied range of pH from 7.24 to 8.23. As per BIS(IS 10500 : 2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Dhangwan (8.23). The ground water of the study area can be assessed as neutral to slightly alkaline. The electrical conductivity of ground water samples in Raisen district varies from 505 to 1425 µS/cm at 25°C. The electrical conductivity from Raisen district shows variability, three samples from Begamganj, Dehgaon and Udaipura villages shows EC in between 1000-1500 µS/cm; the EC of remaining 21 samples is below 1000 µS/cm. So, overall ground water quality in Raisen district is good.

The fluoride concentration in Raisen district lies in between 0.02 to 0.54 mg/l, which represent that all the samples are within the permissible limit i.e. 1.5 mg/l as per BIS (IS 10500 : 2012). The range of Total Hardness (as $CaCO_3$) in ground water samples of study area is 175 to 580 mg/l. In all locations, total hardness concentrations are within the permissible limit of 600 mg/l. the maximum concentration of total hardness observed in the village of Udaipura (580 mg/l).

Piper diagram (figure no. 17) has three parts: a Cation triangle, an Anion triangle, and a Central diamond-shaped field. In Cation triangle, the relative percentages of the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions ($HCO_3^{-}+CO_3^{2-}$, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field. Out of the total ground water samples analyzed from Raisen district, 79.2% of samples are Mixed type, and 20.8% samples shows nature of water as Calcium-Bicarbonate type, hence show temporary hardness. (figure no. 18).

Nitrate in ground water samples of Raisen district fall within limits of 5 to 58 mg/l. It is observed that 20.8% samples have Nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 79.2% samples have concentration less than acceptable limit. Highest nitrate is reported in the water sample collected from Sultanganj (58mg/l). High nitrate in ground water samples may be due to anthropogenic activities or excessive use of fertilizers (figure no.19).

3.4.2 Quality of Ground Water for Irrigation Purpose:

In classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. The chemical data of all the water samples from Raisen district is plotted on U.S. Salinity Laboratory diagram.

It is clear that approx. 50% wells shows that the ground water are C_2-S_1 Class (Medium Salinity & Low Sodium) and 50% wells of study area are observed under C_2-S_1 Class (Medium Salinity & Low Sodium) which means that these waters can be used for irrigation purpose for most of the crops, Water from these areas can be used for irrigation, considering the salinity content of the ground water. Water quality data is given as annexure -2

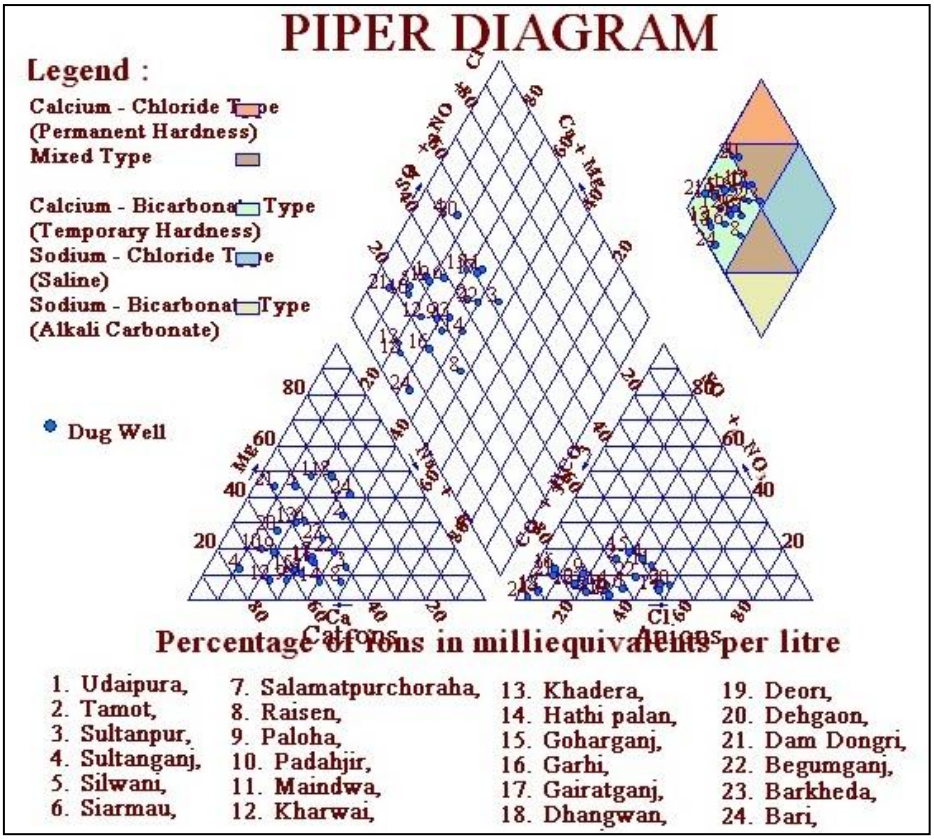


Figure No.17: Hill Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Raisen District, Madhya Pradesh

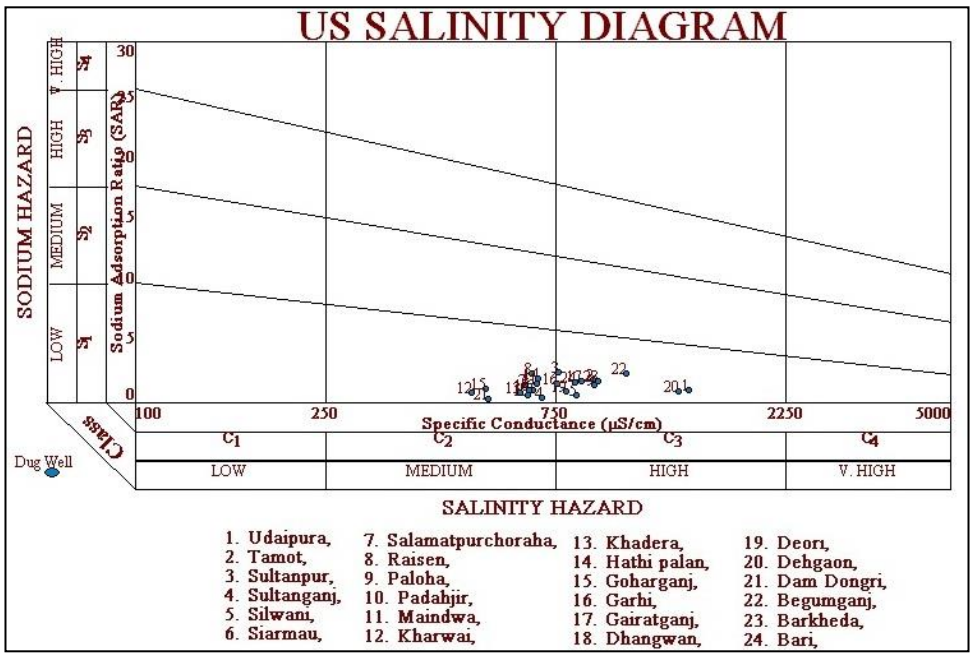


Figure No.18: US Salinity Diagram for water samples collected from National Hydrograph Stations of Raisen District, Madhya Pradesh

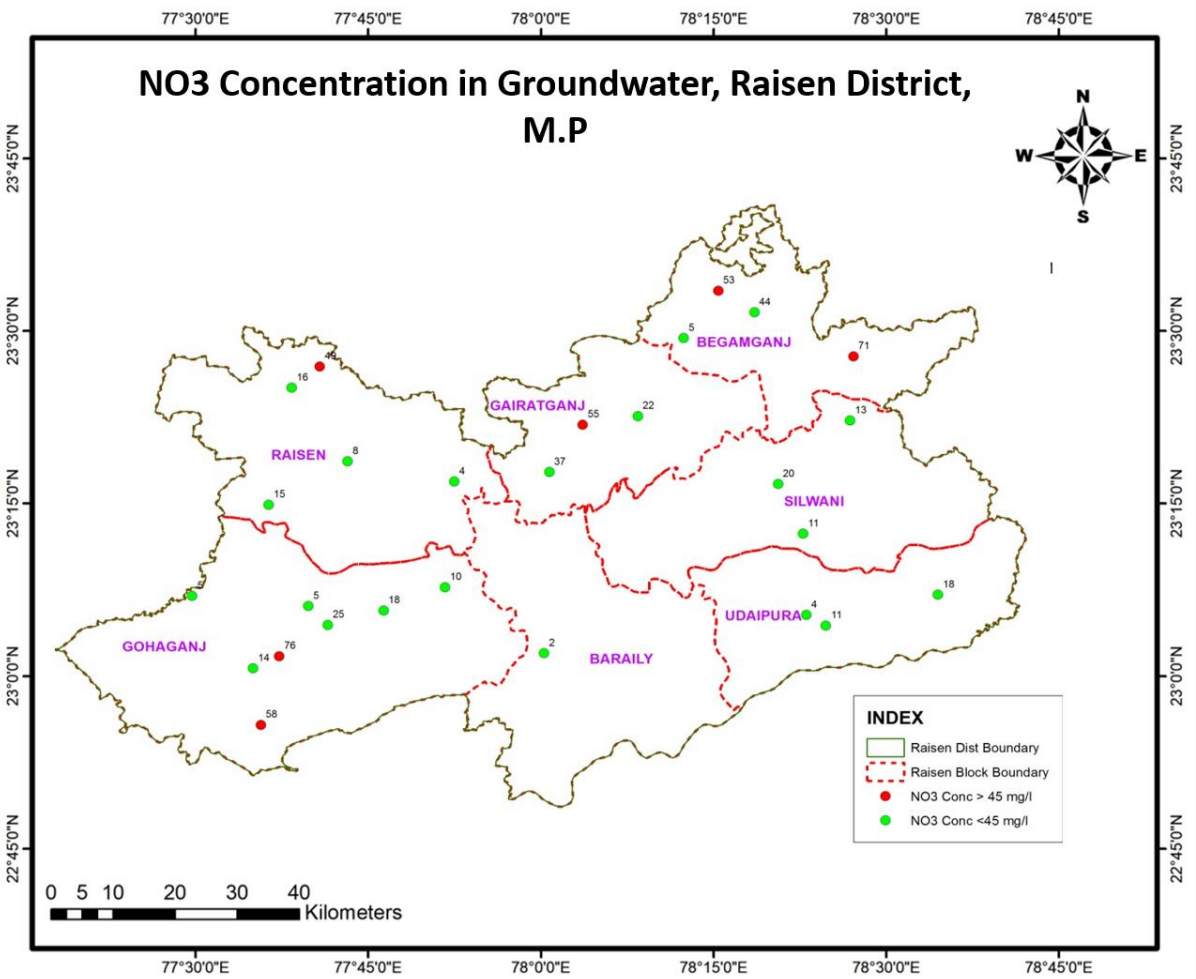


Figure No.19: NO3 Concentration Map of Raisen District

CHAPTER 4
GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resource (2020)

Raisen district is underlain by Alluvium, Deccan Trap Basalt, Vindhyan Shale and Sandstone. Dynamic ground water resources of the district have been estimated on block-wise basis. Out of 8466 sq. km of geographical area, 6609 sq. km(78%) is ground water recharge worthy area and 1857 sq. km is hilly area (21.9%). There are seven assessment units (block) in the district out of which one block fall under command area and the remaining blocks falls under non-command area. One block of the district is categorized as semi-critical namely Obedullaganj(non-command) and rest as safe. The highest stage of ground water development is computed as 71.62% in non-command area of Obedullaganj block. The net ground water availability in the district is 819.49 mcm and ground water Extraction for all uses is 434.95 mcm, making stage of ground water development to 53.08% as a whole for district (Table 7).

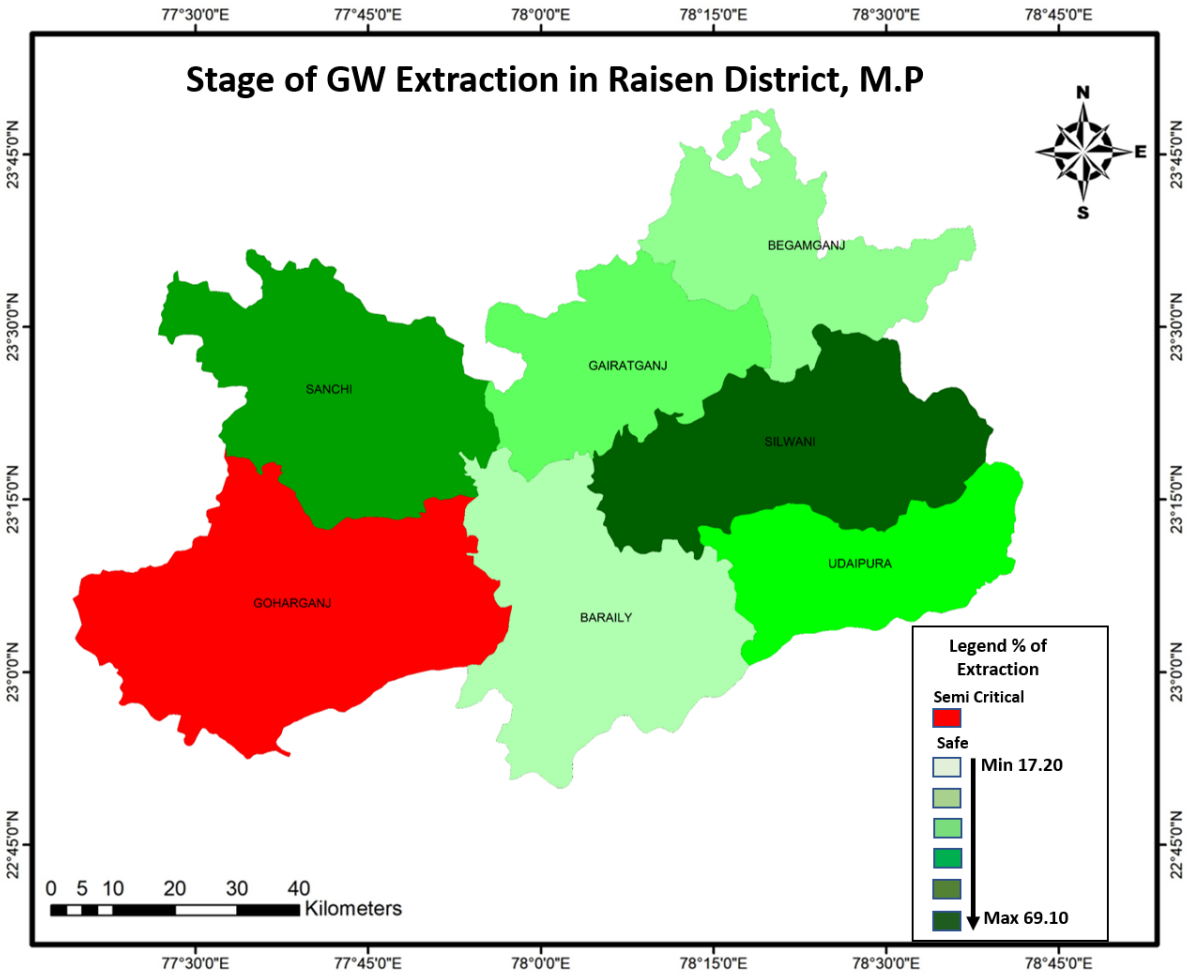


Fig 20**:** Stages of ground water extraction in Raisen district, MP

Table 7: Dynamic Groundwater Resources of Raisen district, March 2020

Assessment Unit / District	Command / Non-Command	Annual Extractable Groundwater Resources Ham	Existing Gross Ground Water Extraction for Irrigation in Ham	Existing Gross Ground Water Extraction for Domestic & Industrial Water Supply in Ham	Existing Gross Ground Water Extraction for All Uses in Ham	Allocation For Domestic & Industrial Water Supply in Ham	Extractable GW for Future Irrigation Development in Ham	Stage of Ground Water Development in %	Category
Badi	Command	13234.36	1196.59	243.69	1440.28	264.59	1180.89	10.88	
	Non-Command	6719.97	1666.25	326.71	1993	354.71	15291.29	29.65	
	Block Total	**19954.33**	**2862.85**	**570.41**	**3433.28**	**619.3**	**16472.19**	**17.20**	**Safe**
Begumganj	Non-Command	9344.53	5343.4	314.69	5658.1	345.38	3655.75	60.55	
	Block Total	**9344.53**	**5343.4**	**314.69**	**5658.1**	**345.38**	**3655.75**	**60.55**	**Safe**
Gairatganj	Non-Command	7890.8	4448.23	341.21	4789.44	379.44	3063.13	60.70	
	Block Total	**7890.8**	**4448.23**	**341.21**	**4789.44**	**379.44**	**3063.13**	**60.70**	**Safe**
Obedullaganj	Non-Command	9420.06	5373	1374.11	6747.1	896	2501.07	71.62	
	Block Total	**9420.06**	**5373**	**1374.11**	**6747.1**	**896**	**2501.07**	**71.62**	**Semi-Critical**
Sanchi	Non-Command	12144.12	7243.99	466.46	7710.45	520.8	4379.33	63.49	
	Block Total	**12144.12**	**7243.992**	**466.46**	**7710.45**	**520.8**	**4379.33**	**63.49**	**Safe**
Silwani	Non-Command	12409.48	8180.44	394.17	8574.61	426.79	3802.25	69.10	
	Block Total	**12409.48**	**8180.44**	**394.17**	**8574.61**	**426.79**	**3802.25**	**69.10**	**Safe**
Udaipura	Non-Command	10785.89	6165.9	416.04	6581.94	459.18	4160.81	61.02	
	Block Total	**10785.89**	**6165.9**	**416.04**	**6581.94**	**459.18**	**4160.81**	**61.02**	**Safe**
District Total		**81949.21**	**39617.81**	**3877.11**	**43494.9**	**3646.89**	**38034.53**	**53.08**	**Safe**

As a part of NAQUIM project 2020-21, groundwater resources of 1st aquifer and second aquifer is calculated using water level fluctuation methods, for each block in Raisen district as given in the tables 8-9 below. Total groundwater resources of the district is compiled in table 10 below.

Table 8: Groundwater Resources of 1st Aquifer

	Unit	Badi	Begumganj	Gairatganj	Obedullaganj	Sanchi	Silwani	Udipura	TOTAL
Recharge worthy Area	Sq km	1418	893	746	864.4	1050	996	642	**6609.4**
Premonsoon (average) depth to water level	m	8.31	9.17	8.42	7.8	7.71	8.21	9.87	
Av. depth of Dug well	m	12.04	12.67	11.12	11.53	11.76	12.47	14.05	
Specific yield (Sy)%	Fraction	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Saturated thickness of aquifer (ST)	m	3.73	3.5	2.7	3.73	4.05	4.26	4.18	
Resource (A * Sy * ST)	**MCM**	**105.8**	**62.5**	**40.3**	**64.5**	**85.1**	**84.9**	**53.7**	**496.64**

Table 9: Static Groundwater Resources of 2nd Aquifer

Static Resources/In-storage									
BLOCK		**Badi**	**Begumganj**	**Gairatganj**	**Obedullaganj**	**Sanchi**	**Silwani**	**Udipura**	**TOTAL**
Recharge worthy Area	Sq km	1418	893	746	864.4	1050	996	642	**6609.4**
Thickness of fracture in deeper aquifer	m	4.5	5.3	5.1	2.8	4.3	3.1	9.5	
Specific yield(Sy)%	Fraction	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Resource (A * Sy * ST)	**MCM**	**127.6**	**94.7**	**76.1**	**48.4**	**90.3**	**61.8**	**122.0**	**620.8**

Table 10: Total groundwater resources of Raisen district

Block	Badi	Begumganj	Gairatganj	Obedullaganj	Sanchi	Silwani	Udaipura	TOTAL
First Aquifer								
Dynamic Resources (MCM) (GWRA 2020)	199.54	93.45	78.90	94.20	121.44	124.09	107.86	819.48
Static Resources (MCM)	105.8	62.5	40.3	64.5	85.1	84.9	53.7	496.64
Total Resources (MCM)	305.32	155.96	119.18	158.68	206.49	208.95	161.53	1316.12
Irrigation	22.90	42.74	35.58	42.98	57.95	65.44	49.32	316.93
Domestic+ Industries	5.70	3.15	3.41	13.74	4.66	3.94	4.16	38.76

GW Extraction (MCM)	28.60	45.89	38.99	56.72	62.61	69.38	53.48	355.69
Second Aquifer								
Static Resources (MCM)	127.6	94.7	76.1	48.4	90.3	61.8	122.0	620.81
GW Extraction for Irrigation (MCM)	5.73	10.69	8.90	10.75	14.49	16.36	12.33	79.23
Total GW Resources (MCM)	**432.94**	**250.62**	**195.28**	**207.09**	**296.79**	**270.70**	**283.51**	**1936.93**
Gross Ground Water Extraction for irrigation (MCM)	28.63	53.43	44.48	53.73	72.44	81.80	61.65	396.16
Gross Ground Water Extraction (MCM)	**34.33**	**56.58**	**47.89**	**67.47**	**77.10**	**85.74**	**65.81**	**434.92**

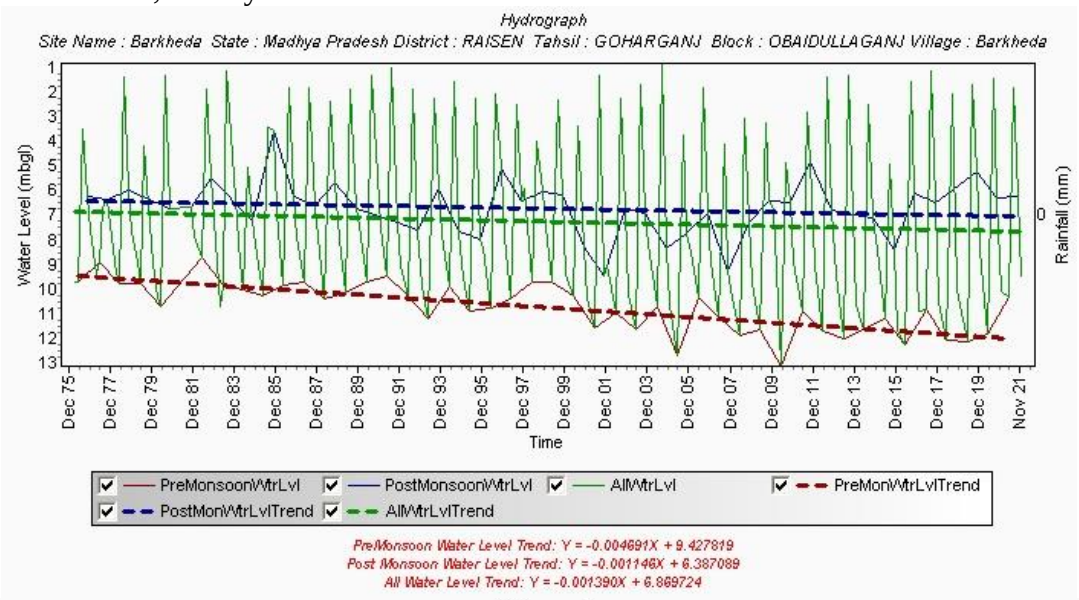
CHAPTER 5

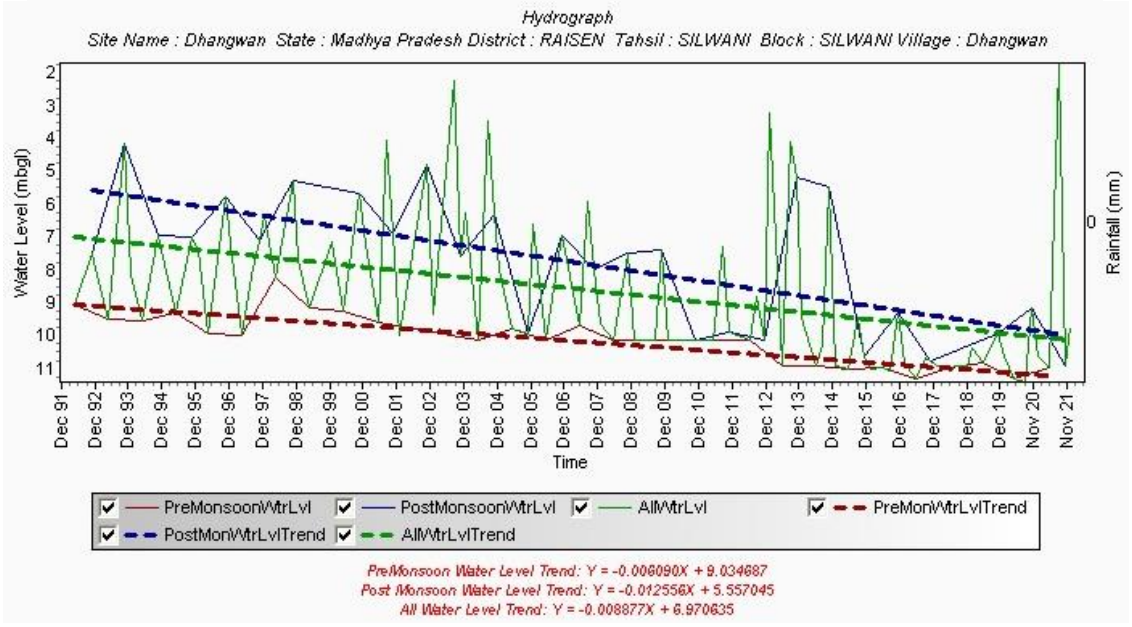
GROUND WATER RELATED ISSUES

5.1 Declining of water level

The long-term water level trend analysis indicates mixed results. During pre-monsoon season, out of 31 National Hydrograph Stations (NHS), hydrographs of two blocks namely Obedullaganj and Silwani shows declining trend in overall water levels. Obedullaganj block is under Semi-Critical category and Silwani block is under safe category with a stage of groundwater extraction of 69.10%. The remaining blocks falls under safe category. However, the pre-monsoon water level trends show a declining trend in Begumganj and Udaipura blocks while Gairatganj, Sanchi and Badi blocks shows nearly constant or rising trends.

Figure No 17,18: Hydrographs showing declining water level trend during Pre-monsoon and Post-Monsoon at sites Barkheda and Dhangwan, Obedullaganj and Silwani blocks, Raisen District, Madhya Pradesh





CHAPTER 6
GROUND WATER MANAGEMENT STRATEGIES AND AQUIFER MANAMGEMENT PLAN

Based on the resources available and extraction, assessment blocks in Raisen districts are categorized into Safe and Semi Critical Categories. Management plan for each assessment unit i.e. blocks are prepared. As Obedullaganj is Semi-critical, artificial recharge is proposed in the block through rainwater harvesting and construction of recharge structures. Block Silwani falls under safe category with stage of groundwater extraction of 69.10% (nearing to 70% as semi critical) and shows declining trend in long term water levels. Hence, artificial recharge structures are proposed in Silwani block as well. Sprinkler irrigation is also proposed in these blocks for reducing groundwater Extraction. In the remaining blocks viz. Begumganj, Gairatganj, Risen and Udaipura artificial recharge is proposed. In Badi block having a stage of groundwater extraction of 17% additional extraction is proposed through construction of extraction structures and additional irrigated area is proposed for wheat and summer crops.
For sustainable development, it is necessary to maintain balance between the recharge and extraction components of groundwater. Therefore, additional extraction is proposed for irrigation, domestic and industrial purpose in Begumganj, Gairatganj, Obedullaganj, Raisen, Silwani and Udaipura blocks. Details of the same are discussed below.

6.1 Calculation and distribution of additional Extraction

In each block, additional Extraction is proposed for sustainable development of groundwater. Based on existing annual extractable groundwater resources available in each block, additional Extraction is calculated so that the stage of groundwater extraction may increase to 60-70%.
50% of the total additional Extraction calculated is proposed for domestic and industrial purpose and the remaining 50% is proposed for utilising for agriculture.

6.1.1 Distribution of additional extraction for domestic and industrial purpose

50% of this additional Extraction proposed may be utilized for domestic and industrial uses. Hydrogeologically, major part of the district is covered by basaltic aquifer. Hence 70% of the Extraction is proposed to be extracted from dug wells (shallow aquifer). The remaining 30% is proposed to be extracted from additional bore wells constructed in area underlained by Shale, limestone, Granite etc. (deep aquifer). Number of additional dug well and bore well is calculated by dividing the Extraction proposed by unit Extraction during non-monsoon season of dug well and bore well in the block respectively.

6.1.2 Distribution of additional extraction for agriculture

Being a tribal district, agricultural area utilised in Raisen district is comparatively less in Mandla district. Therefore, remaining 50% of additional Extraction proposed, may be utilised for agricultural purposes for economic development of the district. 60% of the Extraction proposed, may be utilised for cultivation of wheat. As per the Indian Council of Agricultural Research, average crop water requirement of wheat is 0.4 m. The additional area for cultivation of wheat is calculated based on this standard norm. 20% of the additional Extraction proposed may be utilized for cultivation summer crops including corn, coarse cereals, tomato, cucumber etc. The standard crop water requirement of these crops is assigned as 0.2 m. The remaining 20% of the Extraction proposed may be utilized for cultivation of short-term crops so that double/triple cropping can be practiced in the district. Water requirement of these crops varies from 0.2m to 0.4m as per ICAR. Based on this standard area for double/triple cropping is calculated for each block.

Table 11: Subsurface storage calculated for Raisen district

Block	Rainfall (mm)	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available	Non-committed Run-off
Obedullaganj	1368.09	1.36809	1749	864.4	4.9	1.9	0.02	16.424	21.84	354.77	106.43
Raisen	1368.09	1.36809	1360	1050	4	1	0.02	10.50	13.97	430.95	129.28
Begumganj	1368.09	1.36809	912	893	4.37	1.37	0.02	12.23	16.27	366.51	109.95
Gairatganj	1368.09	1.36809	920	746	4.09	1.09	0.02	8.13	10.81	306.18	91.85
Silwani	1368.09	1.36809	1289	996	5.02	2.02	0.02	20.12	26.76	408.79	122.64
Udaipura	1368.09	1.36809	817	642	4.42	1.42	0.02	9.12	12.12	263.49	79.05

6.1 Management plan of Obedullaganj and Silwani Blocks

In Obedullaganj block, the existing stage of groundwater extraction is 71.62% and for Silwani block, existing stage of groundwater extraction is 69.10% and long-term water trend is showing declining trend in these blocks. Therefore, for sustainable development of groundwater, artificial recharge structures are proposed in both blocks for rainwater harvesting and augmentation of groundwater. In addition to the artificial recharge structures, micro-irrigation techniques are also proposed in both blocks for reducing Extraction. For sustainable development of groundwater, it is necessary to maintain the balance between input and output components of groundwater resources. Thus, additional Extraction is proposed for domestic, industrial and irrigation purpose in Obedullaganj and Silwani blocks.

Average post monsoon water level of Obedullaganj block based on NHS monitoring wells is 4.9m and the unsaturated zone available in the block is 1.9m which is the space available for recharge. The subsurface storage calculated is 16.42mcm and the non-committed runoff available is 106.43 mcm. Based on this data, a recharge plan had been proposed for Obedullaganj block (Table No.12).

Average post monsoon water level of Silwani block based on NHS monitoring wells is 5.02m and the unsaturated zone available in the block is 2.02m which is the space available for recharge. The subsurface storage calculated is 20.12mcm and the non-committed runoff available is 122.64 mcm. Based on this data, a recharge plan had been proposed for Silwani block (Table no.12).

Table 12: Proposed Artificial Recharge structures in Obedullaganj and Silwani Blocks

Block	Subsurface Storage available (mcm)	Non-committed runoff available (mcm)	Structures feasible	Percolation Tank (0.2 cr.)	Check Dam with Recharge Shaft/Tube Well (0.061cr.)	Nala Bund/Concrete Plug (0.01cr.)	Renovation of farm/village pond (0.025cr.)	Total
Obedullaganj	**16.42**	106.43	Number	16	12	49	27	104
			Cost(cr.)	3.2	0.732	0.49	0.675	5.097
Silwani	**20.12**	122.64	Number	20	15	60	34	129
			Cost(cr.)	4	0.915	0.6	0.85	6.365

In Obedullaganj block, 16 percolation tanks, 12 check dam with tube well/ recharge shaft and 49 Nala bunds/concrete plug is proposed which is 35%, 45% and15% of the subsurface storage available. Renovation of 27 village ponds are also proposed which is 5% of the subsurface storage available in Obedullaganj block. The total cost of structures is 5.097 crores.

In Silwani block, 20 Percolation Tanks, 15 Check Dam with tube well/ recharge shaft and 60 Nala bunds/concrete plug is proposed which is 35%, 45% and15% of the subsurface storage available. Renovation of 34 Village Ponds are also proposed which is 5% of the subsurface storage available in Silwani block. The total cost of production is 6.365 crores.

In addition to the recharge structures, micro-irrigation is also proposed in Obedullaganj and Silwani blocks by sprinkler irrigation method. According to Anand et.al., (2012), 20% water can be saved by adopting sprinkler irrigation in basaltic terrain (table 13).

Table 13: Proposed savings by sprinkler for Obedullaganj Block

Block	Annual extractable groundwater (mcm)	Annual Extraction for Irrigation (mcm)	Gross annual Extraction (mcm)	Stage of Extraction of groundwater (%)	Savings by Sprinkler (@20%) (mcm)
Obedullaganj	94.20	53.73	67.47	**71.62**	10.75
Silwani	124.09	81.8	85.7	**69.10**	16.36

After implementation of recharge structures in Obedullaganj block, total additional recharge will be 16.42 mcm which increase the dynamic groundwater resources to 110.62 mcm. The additional savings by micro-irrigation in Obedullaganj block is 10.75 mcm which can cause a reduction in the gross Extraction. Similarly, in Silwani block after implementation of recharge structures, total recharge is 20.12mcm which increase the

dynamic resources to 144.21 mcm. The additional savings by micro-irrigation in Silwani block is 16.36 mcm which can cause a reduction in the gross extraction.
Together the recharge structures and the micro-irrigation will be able to increase the utilization of more area for irrigation and cropping and reduce the stage of groundwater extraction in Obedullaganj and Silwani blocks and hence increase the sustainability of aquifer.

Table 14: Proposed additional Extraction for Obedullaganj and Silwani Blocks

Block	**Additional Extraction Proposed through new abstraction structures for Domestic/ Industrial (mcm)**		**No. of Structures for Domestic/Industrial**		**Additional Extraction Proposed for irrigation (mcm)**			**Additional Irrigated Area proposed to be Created (sq.km)**			**Gross additional Extraction proposed (mcm)**
	Dug Well	**Bore Well**	**Dug well**	**Bore Well**	**Wheat**	**Summer Crops**	**Double/triple cropping**	**Wheat**	**Summer Crops**	**Double/triple cropping**	
Obedullaganj	3.10	1.33	8	2	2.65	0.88	0.88	6.64	2.95	2.21	8.85
Silwani	5.05	2.16	8	2	2.65	0.88	0.88	6.64	2.95	2.21	14.42

In Obedullaganj block, total additional Extraction proposed is 8.85mcm, which is 8% of net groundwater availability of dynamic resources. This is proposed for sustainable development of groundwater in parts of the block where groundwater development is less. In this 50% is utilized for domestic and industrial purpose through 8 new dug wells (70%) and 2 new bore wells (30%). The remaining 50% is utilized through additional irrigation in block. Wheat is proposed in 6.64 sq.km additional area which will utilise the 60% of additional Extraction, 2.65mcm. In the remaining area, 2.95 sq.km is proposed for summer crops which will utilise 20% of additional Extraction, 0.88mcm and 2.21sq.km is proposed for double/triple cropping which will utilise 20% of additional Extraction, 0.88 mcm.
In Silwani block, total additional Extraction proposed is 14.42 mcm, which is 10% of net groundwater availability of dynamic resources. This is proposed for sustainable development of groundwater in parts of the block where groundwater development is less. In this 50% is utilized for domestic and industrial purpose through 8 new dug wells (70%) and 2 new bore wells (30%). The remaining 50% is utilized through additional

irrigation in block. Wheat is proposed in 10.82 sq.km additional area which will utilise the 60% of additional Extraction, 4.33 mcm. In the remaining area, 4.81 sq.km is proposed for summer crops which will utilise 20% of additional Extraction, 1.44mcm and 3.61 sq.km is proposed for double/triple cropping which will utilise 20% of additional Extraction, 1.44 mcm.

6.3 Management Plan of Badi Block

The existing stage of groundwater extraction in Badi block is 17.20%, total dynamic groundwater resource available is 199.54mcm. gross groundwater Extraction for all uses from dynamic and static aquifer is 34.33mcm. Based on the available data, management plan had been prepared for Badi block based on the methodology discussed above. The proposed management plan is given in table 15.

Table 15: Proposed Management plan for Badi Block

Block	**Additional Extraction Proposed through new abstraction structures for Domestic/Industrial (mcm)**		**No. of Structures for Domestic/Industrial**		**Additional Extraction Proposed for irrigation (mcm)**			**Additional Irrigated Area proposed to be Created (sq.km)**			**Gross additional extraction proposed (30% of Annual Extractable GW)**
Badi	**Dug Well**	**Bore Well**	**Dug well**	**Bore Well**	**Wheat**	**Summer Crops**	**Double/triple cropping**	**Wheat**	**Summer Crops**	**Double/triple cropping**	
	20.95	8.98	72	15	17.96	5.99	5.99	44.90	19.95	14.97	59.86

In Badi block, total additional Extraction proposed is 59.86mcm, which is 30% of net groundwater availability of dynamic resources. In this 50% is utilized for domestic and industrial purpose through 72 new dug wells (70%) and 15 new bore wells (30%). The remaining 50% is utilized through additional irrigation in block. Wheat is proposed in 44.90sq.km additional area which will utilise the 60% of additional Extraction, 17.96mcm. In the remaining area, 19.95sq.km is proposed for summer crops which will utilise 20% of additional Extraction, 5.99mcm and 14.97sq.km is proposed for double/triple cropping which will utilise 20% of additional Extraction, 5.99mcm.

6.4 Management plan of Begumganj, Gairatganj, Raisen and Udaipura blocks

In the Begumganj, Gairatganj, Raisen and Udaipura blocks, stage of groundwater extraction is 60.55%, 60.70%, 63.49% and 61.02% respectively and the long-term water shows rising trend. In these blocks, additional Extraction is proposed. Along with this, artificial recharge structures are proposed for sustainable development of groundwater (table 16-17).

Table 16: Artificial Recharge Plan proposed for Begumganj, Gairatganj, Raisen and Udaipura Blocks

Block	Subsurface Storage available (mcm)	Non-committed runoff available (mcm)	Structures feasible	Percolation Tank (0.2 cr.)	Check Dam with Recharge Shaft/Tube	Nala Bund/Concrete Plug (0.01cr.)	Renovation of farm/village pond pond (0.025cr.)	Total
Begumganj	16.27	109.95	Number	12	9	37	20	**78**
			Cost(cr.)	2.4	0.55	0.37	0.5	**3.82**
Gairatganj	10.81	91.85	Number	8	6	24	14	**52**
			Cost(cr.)	1.6	0.37	0.24	0.35	**2.56**
Raisen	10.50	129.28	Number	11	8	32	18	**69**
			Cost(cr.)	2.2	0.49	0.32	0.45	**3.46**
Udaipura	9.12	79.05	Number	9	7	27	15	**58**
			Cost(cr.)	1.8	0.43	0.27	0.36	**2.87**
Total	57.42	584.74	Number	**40**	**30**	**120**	**67**	**257**
			Cost(cr.)	**11.4**	**2.62**	**1.72**	**2.4**	**18.15**

In Begumganj, Gairatganj, Raisen and Udaipura blocks of Raisen district, total 40 percolation tanks, 30 check dam with tube well/ recharge shaft and 120 Nala bunds/concrete plug is proposed which is 35%, 45% and15% of the subsurface storage available. Renovation of 67 village ponds is also proposed which is 5% of the subsurface storage available. The total cost of production is 12.7 crores (figure no. 19)
After implementation of recharge structures, total recharge is 39.98mcm which increase the dynamic resources to 441.63 mcm which reduce the stage of groundwater extraction in 4 blocks of Raisen district and hence increase the sustainability of aquifer.

Table 17: Additional extraction proposed for Begumganj, Gairatganj, Raisen and Udaipura Blocks

Block	Additional Extraction Proposed through new abstraction structures for Domestic/ Industrial (mcm)		No. of Structures for Domestic/ Industrial		Additional Extraction Proposed for irrigation (mcm)			Additional Irrigated Area proposed to be Created (sq.km)			Gross additional extraction proposed
	Dug Well	Bore Well	Dug well	Bore Well	Wheat	Summer Crops	Double/triple cropping	Wheat	Summer Crops	Double/triple cropping	(mcm)
Begumganj	2.96	1.27	4	1	2.54	0.85	0.85	6.34	2.82	2.11	8.45
Gairatganj	1.52	0.65	2	1	1.31	0.44	0.44	3.26	1.45	1.09	4.35
Raisen	2.77	1.19	6	1	2.37	0.79	0.79	5.94	2.64	1.98	7.92
Udaipura	2.05	0.88	4	1	1.75	0.58	0.58	4.39	1.95	1.46	5.85
Total	9.30	3.99	16	4	7.97	2.66	2.66	19.93	8.86	6.64	26.57

In Begumaganj, Gairatganj, Raisen and Udaipura blocks additional Extraction proposed is 8.45mcm, 4.35mcm, 7.92mcm and 5.85mcm which is 8%, 5%, 6% and 5% of net groundwater availability of dynamic resources respectively. Total additional Extraction proposed is 26.57mcm. In this 50% is utilized for domestic and industrial purpose through 16 new dug wells (70%) and 4 new bore wells (30%). The remaining 50% is utilized through additional irrigation in block. Wheat is proposed in 19.93sq.km additional area which will utilise the 60% of additional Extraction, 7.97mcm. In the remaining area, 8.86 sq.km is proposed for summer crops which will utilise 20% of additional Extraction, 2.66mcm and 6.64sq.km is proposed for double/triple cropping which will utilise 20% of additional Extraction, 2.66mcm.
After construction of recharge structures and extraction of the additional groundwater, gross Extraction will be 273.9mcm and net groundwater availability will be 415.06mcm (table 22).

Table no.18: Projected groundwater availability and stage of extraction

Block	Existing Gross Extraction 2020 (1) (mcm)	Additional Extraction Proposed (2) (mcm)	Savings by Sprinkler (3)	Projected Extraction after additional Extraction 4(1+2) (mcm)	Additional GW created by Artificial Recharge (5) (mcm)	Annual Extractable groundwater resources 2020 (6) (mcm)	Projected extractable groundwater resources (3+5+6) (mcm)	Existing Stage of groundwater Extraction 2020 (%)	Projected Stage of groundwater Extraction (%)
Badi	34.33	59.86	-	94.19	-	199.54	199.54	17.20	47.20
Begumganj	56.58	8.45	-	65.04	16.72	93.44	110.16	60.55	59.03
Gairatganj	47.89	4.35	-	52.25	10.81	78.90	89.71	60.70	58.23
Obedullaganj	67.47	8.5	10.75	76.32	16.42	94.20	121.37	71.62	62.59
Raisen	77.10	7.92	-	85.02	10.50	121.44	131.94	63.49	64.44
Silwani	85.75	14.42	16.36	100.17	20.12	124.09	160.57	69.10	62.38
Udaipura	65.82	5.85	-	71.67	9.12	107.86	116.98	61.02	61.27
Total	**434.94**	**109.7**	**27.11**	**544.66**	**83.69**	**819.47**	**930.27**	**53.08**	**58.55**

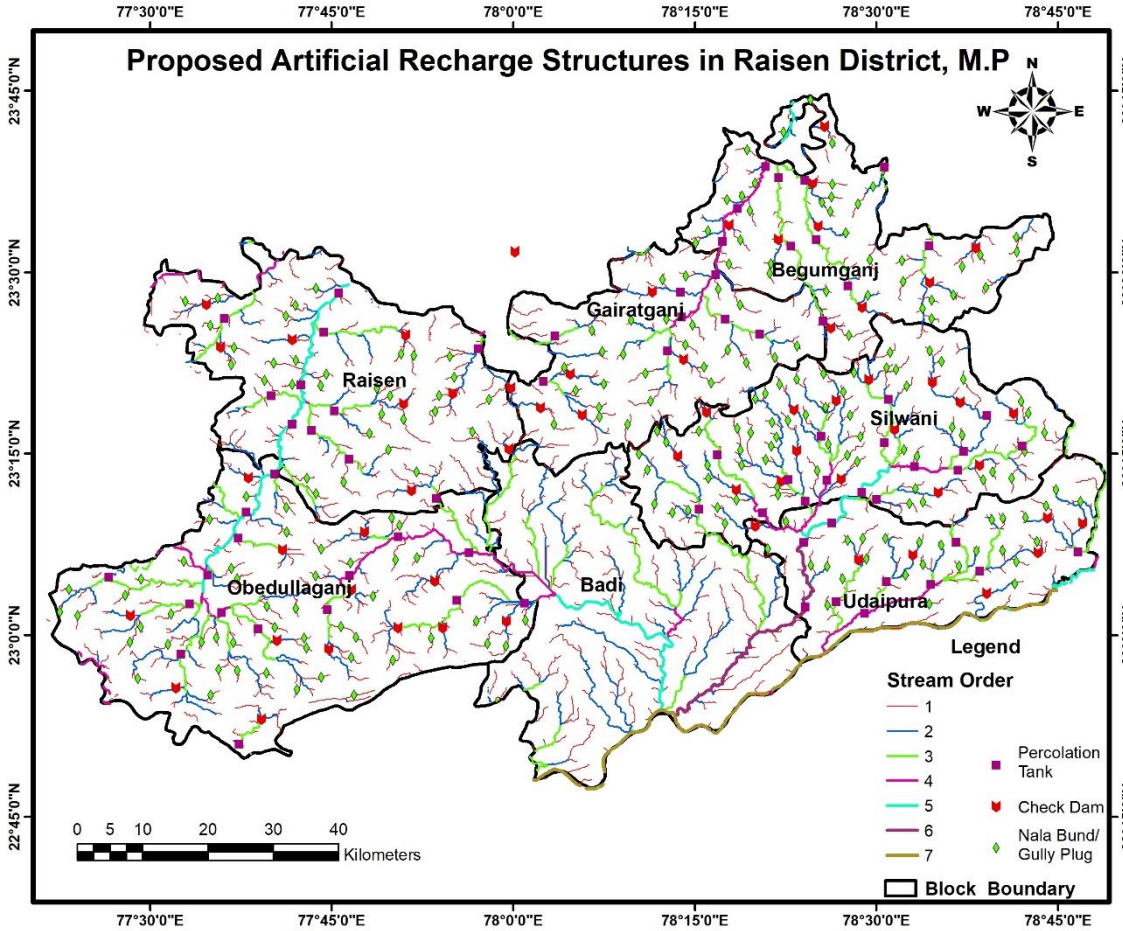


Figure. No.21: Artificial Recharge structures proposed in Raisen district, M.P

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONSS

7.1 Conclusions

Total Geographical Raisen district is of 8466 sq. km. 6609 sq. km (78%) is ground water recharge worthy area and 1857 sq. km is hilly area (21.9%).
There are seven assessment units (block) in the district out of which one block fall under command area and the remaining blocks falls under non-command area.
One block of the district is categorized as semi-critical namely Obedullaganj(non-command) and remaining blocks namely Badi, Begumganj, Gairatganj, Raisen, Silwani and Udaipura are safe.
The highest stage of ground water development is computed as 71.62% in non-command area of Obedullagnaj block.
The annual extractable groundwater resources in the district is 819.49 mcm and ground water Extraction for all uses is 434.95 mcm.
Management plan for each block is prepared based on the stage of groundwater extraction, sub surface storage and non-committed runoff available for recharge.
As Obedullaganj is Semi-critical, artificial recharge is proposed in the block through rainwater harvesting and construction of recharge structures.
Block Silwani falls under safe category with stage of groundwater extraction of 69.10% and shows declining trend in long term water levels. Hence, artificial recharge structures are proposed in Silwani block as well. Sprinkler irrigation is proposed in Obedullaganj and Silwani blocks for reducing groundwater Extraction.
Among the remaining blocks, Badi block is having a stage of groundwater extraction of 17.20% where additional Extraction is proposed through construction of extraction structures and additional irrigated area is proposed for wheat and summer crops.
In the remaining blocks namely Begumganj, Gairatganj, Raisen and Udaipura, where stage of groundwater extraction is between 60-65%, additional Extraction is proposed. Along with this, artificial recharge structures are proposed for sustainable development of groundwater.

7.2 Recommendations

- Proposed artificial recharge structures may be constructed in Begumganj, Gairatganj, Obedullaganj Sanchi, Silwani and Udaipura blocks.
- Proposed micro-irrigation technique may be adopted in Obedullaganj and Silwani blocks.
- Additional Extraction may be utilized and additional area for irrigation may be created in Badi, Begumganj, Gairatganj, Sanchi and Udaipura blocks.
- In Silwani, Obedullaganj Gairatganj and Udaipura blocks, high frequency monitoring of water levels and impact assessment studies may be carried out as both as these blocks are showing declining trend in water level.

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Annexure – 1

Litholog of Exploratory Wells in Raisen District

Litholog of Banspipalia					
Depth (mbgl)				RL (mamsl)	
From	To	Litholog	Thickness	From	To
0	3.1	Soil	3.1	314.2	311.1
3.1	15.5	Yellow Clay (Alluvium)	12.4	311.1	298.7
15.5	27.5	Sand/Kankar (Alluvium)	12	298.7	286.7
27.5	39.5	Sand(Alluvium)	12	286.7	274.7
39.5	42.25	Clay (Alluvium)	2.75	274.7	271.95
42.25	48	Sand(Alluvium)	5.75	271.95	266.2
48	73	Clay with Kanakr and Laterite	25	266.2	241.2
73	81	Laterite (Alluvium)	8	241.2	233.2
81	94.88	Sandstone	13.88	233.2	219.32

Litholog of Begumganj					
Depth (mbgl)				RL (mamsl)	
From	To	Litholog	Thickness	From	To
0	2.1	Soil	2.1	510.3	508.2
2.1	3.15	Yellow Clay	1.05	508.2	507.15
3.15	5.75	Weathered Basalt	2.6	507.15	504.55
5.75	7.8	Fractured/Joined Basalt	2.05	504.55	502.5
7.8	10.8	Redbole	3	502.5	499.5
10.8	11.8	Vesicular Basalt	1	499.5	498.5
11.8	16.6	Massive/Jointed Basalt	4.8	498.5	493.7
16.6	18.97	Vesicular Basalt	2.37	493.7	491.33
18.97	21.02	Massive/Jointed Basalt	2.05	491.33	489.28
21.02	24.07	Vesicular Basalt????	3.05	489.28	486.23
24.07	26.07	Massive Basalt	2	486.23	484.23
26.07	27.12	Vesicular Basalt	1.05	484.23	483.18
27.12	34.2	Fractured/Joined Basalt	7.08	483.18	476.1
34.2	39.3	Massive/Jointed Basalt	5.1	476.1	471
39.3	39.9	Vesicular Basalt	0.6	471	470.4
39.9	42.37	Vesicular Basalt	2.47	470.4	467.93
42.37	48	Massive Basalt	5.63	467.93	462.3
48	49.8	Redbole	1.8	462.3	460.5
49.8	53.52	Vesicular Basalt	3.72	460.5	456.78
53.52	59	Massive Basalt	5.48	456.78	451.3
59	60.65	Clay	1.65	451.3	449.65
60.65	66.75	Vesicular Basalt	6.1	449.65	443.55
66.75	70	Massive Basalt	3.25	443.55	440.3

70	73.8	Vesicular Basalt	3.8	440.3	436.5
73.8	84	Massive Basalt	10.2	436.5	426.3
84	85.05	Clay	1.05	426.3	425.25
85.05	91.15	Vesicular Basalt	6.1	425.25	419.15
91.15	100	Fractured/Joined Basalt	8.85	419.15	410.3
100	103.5	Massive Basalt	3.5	410.3	406.8
103.5	105.3	Clay	1.8	406.8	405
105.3	108	Clay	2.7	405	402.3
108	111.45	Vesicular Basalt	3.45	402.3	398.85
111.45	148.6	Massive Basalt	37.15	398.85	361.7
148.6	149	Vesicular Basalt	0.4	361.7	361.3
149	152	Redbole	3	361.3	358.3
152	169	Fractured/Joined Basalt	17	358.3	341.3
169	178.05	Massive Basalt	9.05	341.3	332.25

Litholog of Gairatganj					
Depth (mbgl)		**Litholog**	**Thickness**	**RL (mamsl)**	
From	**To**				
0	2.1	Soil	2.1	551	548.9
2.1	5.7	Yellow Clay with Basaltic pebbles	3.6	548.9	545.3
5.7	6.7	Weathered Basalt	1	545.3	544.3
6.7	10.8	Fractured/Joined Basalt	4.1	544.3	540.2
10.8	15.9	Vesicular Basalt	5.1	540.2	535.1
15.9	31.2	Massive Basalt	15.3	535.1	519.8
31.2	33.2	Intertrappean	2	519.8	517.8
33.2	35.2	Vesicular Basalt	2	517.8	515.8
35.2	46	Massive/Jointed Basalt	10.8	515.8	505
46	47.4	Clay	1.4	505	503.6
47.4	56.5	Vesicular Basalt????	9.1	503.6	494.5
56.5	88	Massive Basalt	31.5	494.5	463
88	91.6	Redbole	3.6	463	459.4
91.6	95	Vesicular Basalt	3.4	459.4	456
95	97.5	Massive/Jointed Basalt	2.5	456	453.5
97.5	100	Vesicular Basalt	2.5	453.5	451
100	112.6	Massive Basalt	12.6	451	438.4
112.6	118	Vesicular Basalt	5.4	438.4	433
118	127	Massive Basalt	9	433	424
127	129	Vesicular Basalt	2	424	422
129	140.5	Massive Basalt	11.5	422	410.5
140.5	142.4	Redbole	1.9	410.5	408.6
142.4	149.1	Vesicular Basalt	6.7	408.6	401.9

149.1	162.4	Massive Basalt	13.3	401.9	388.6
162.4	171	Redbole/Clay	8.6	388.6	380
171	184.6	Vesicular Basalt????	13.6	380	366.4
184.6	191.79	Massive Basalt	7.19	366.4	359.21

Litholog of Kaniwara					
Depth (mbgl)				**RL (mamsl)**	
From	**To**	**Litholog**	**Thickness**	**From**	**To**
0	3	Soil	3	333	330
3	18.9	Clay (Alluvium)	15.9	330	314.1
18.9	24.5	Sandy clay(Alluvium)	5.6	314.1	308.5
24.5	27	Sand(Alluvium)	2.5	308.5	306
27	30.5	Clay with Kanakar (Alluvium)	3.5	306	302.5
30.5	45.5	Gravel(Alluvium)	15	302.5	287.5
45.5	51.6	Dolomitic Limestone	6.1	287.5	281.4

Litholog of Kahrguan					
Depth (mbgl)				**RL (mamsl)**	
From	**To**	**Litholog**	**Thickness**		
0	3.1	Soil	3.1	333.6	330.5
3.1	16	Yellow Clay (Alluvium)	12.9	330.5	317.6
16	26.5	Clay with Kankar (Alluvium)	10.5	317.6	307.1
26.5	31	Kankar(Alluvium)	4.5	307.1	302.6
31	34	Clay (Alluvium)	3	302.6	299.6
34	38.57	Sand(Alluvium)	4.57	299.6	295.03
38.57	38.71	Basalt??	0.14	295.03	294.89

Litholog of Munirgarh					
Depth (mbgl)				**RL (mamsl)**	
From	**To**	**Litholog**	**Thickness**	**From**	**To**
0	2.85	Soil/Clay	2.85	440.9	438.05
2.85	10.95	Clay	8.1	438.05	429.95
10.95	14	Clay/siliceous sandstone	3.05	429.95	426.9
14	17.05	Basaltic pebbles	3.05	426.9	423.85
17.05	19.85	Weathered/vesicular basalt	2.8	423.85	421.05
19.85	24.95	Massive Basalt	5.1	421.05	415.95
24.95	27.6	Vesicular Basalt	2.65	415.95	413.3
27.6	33.1	Clay/Weathered/Redbole	5.5	413.3	407.8
33.1	36.15	Fractured Sandstone	3.05	407.8	404.75
36.15	42.25	Massive Sandstone/Shale	6.1	404.75	398.65

Litholog of Sanchi					
Depth (mbgl)		Litholog	Thickness	RL (mamsl)	
From	To				
0	0.5	Soil	0.5	440.8	440.3
0.5	2.5	Yellow Clay (Alluvium)	2	440.3	438.3
2.5	6	Weathered	3.5	438.3	434.8
6	18	Sand, Clay(Alluvium)	12	434.8	422.8
18	30	Sandstone	12	422.8	410.8

Litholog of Ubaidullaganj					
Depth (mbgl)		Lithology	Thickness	RL (mamsl)	
From	To			From	To
0	4.08	Soil/clay	4.08	448	443.92
4.08	19.33	Clay yellow, Snady	15.25	443.92	428.67
19.33	20.43	Weathered Basalt	1.1	428.67	427.57
20.43	23.75	Massive Basalt	3.32	427.57	424.25
23.75	27.8	Vesicular Basalt	4.05	424.25	420.2
27.8	43	Massive Basalt	15.2	420.2	405
43	44	Weathered Basalt	1	405	404
44	76	Massive Basalt	32	404	372
76	78	Clay	2	372	370
78	88	Weathered Basalt	10	370	360
88	92	Redbole	4	360	356
92	98.93	Redbole with clay,weathered	6.93	356	349.07
98.93	105.03	Sandstone	6.1	349.07	342.97
105.03	117.23	Shale	12.2	342.97	330.77
117.23	125.38	Sandstone	8.15	330.77	322.62

Litholog of Untaikalan					
Depth (mbgl)		Litholog	Thickness	RL(mamsl)	
From	To				
0	4	Soil	4	325	321
4	5.5	Clay (Alluvium)	1.5	321	319.5
5.5	12	Clay with Kanakar (Alluvium)	6.5	319.5	313
12	14.5	Kankar(Alluvium)	2.5	313	310.5

14.5	31.5	Sand(Alluvium)	17	310.5	293.5
31.5	33	Clay(Alluvium)	1.5	293.5	292
33	35.5	Gravel, Sand (Alluvium)	2.5	292	289.5
35.5	38.8	Sandy Clay(Alluvium)	3.3	289.5	286.2
38.8	40.5	Sand(Alluvium)	1.7	286.2	284.5
40.5	44	Redbole	3.5	284.5	281
44	45.7	Massive Basalt	1.7	281	279.3

Annexure-2
Chemical Quality of ground water in Raisen district

S. No.	District	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
						at 25° C	µS/cm at 25°C	mg/liter													
1	Raisen	Bareli	Bari	23.03127	78.0777	8.22	825	30	405	12	3	5	0.54	BDL	23	270	40	41	63	2.1	536
2	Raisen	Obaidullaganj	Barkheda	22.9167	77.6512	7.81	922	0	368	100	4	8	0.10	0.1	25	305	78	27	70	1.1	599
3	Raisen	Begamganj	Begumganj	23.607	78.349	7.32	1055	0	344	135	6	52	0.10	BDL	32	315	86	24	96	1.0	686
4	Raisen	Obaidullaganj	Dam Dongri	23.099	77.838	7.60	545	0	266	17	10	20	0.13	0.2	43	250	52	29	9	0.5	354
5	Raisen	Gairatganj	Dehgaon	23.3187	78.0883	7.24	1357	0	362	237	4	48	0.12	BDL	22	565	152	45	50	1.2	882
6	Raisen	Udaipura	Deori	23.12396	78.6846	7.62	792	0	314	85	6	6	0.10	0	27	315	96	18	35	0.9	515
7	Raisen	Silwani	Dhangwan	23.21908	78.51974	8.23	663	12	332	15	5	8	0.18	BDL	32	250	36	39	36	0.5	431
8	Raisen	Gairatganj	Gairatganj	23.408	78.226	7.89	852	0	248	140	11	6	0.29	BDL	25	275	84	16	65	0.9	554
9	Raisen	Gairatganj	Garhi	23.219	78.1413	7.93	758	0	356	20	8	48	0.30	BDL	32	250	84	10	55	1.1	493
10	Raisen	Obaidullaganj	Gohargan j	23.026	77.679	7.64	540	0	157	52	30	20	0.05	BDL	43	180	60	7	34	1.9	351
11	Raisen	Obaidullaganj	Hathi Palan	23.076	77.753	7.58	694	0	272	70	8	17	0.19	BDL	38	205	72	6	64	1.0	451
12	Raisen	Sanchi	Khadera	23.305	77.945	7.85	637	0	332	15	8	6	0.31	0.1	22	245	60	23	30	1.1	414
13	Raisen	Sanchi	Kharwai	23.2672	77.6636	7.74	505	0	229	30	8	11	0.15	BDL	30	190	68	5	27	0.7	328
14	Raisen	Obaidullaganj	Maindwa	23.1218	77.5449	7.53	690	0	181	90	25	23	0.06	BDL	28	220	68	12	54	1.1	449

15	Raisen	Begamganj	Padahjir	23.573	78.404	7.5	660	0	296	40	15	6	0.2	BDL	30	275	84	16	22	0.9	429
16	Raisen	Begamganj	Paloha	23.532	78.296	7.25	906	0	380	57	8	47	0.07	BDL	42	315	112	9	60	1.2	589
17	Raisen	Sanchi	Raisen	23.336	77.783	7.66	672	0	296	55	5	7	0.5	BDL	25	175	60	6	73	0.5	437
18	Raisen	Sanchi	Salamatpurchoraha	23.453	77.698	7.88	650	0	278	47	12	13	0.29	BDL	25	215	64	13	48	2.1	423
19	Raisen	Silwani	Siarmau	23.401	78.55	8.02	675	0	248	82	8	9	0.36	0.1	22	255	60	26	36	1.8	439
20	Raisen	Silwani	Silwani	23.2949	78.4471	7.66	832	0	368	65	6	12	0.17	BDL	26	355	68	45	26	1.1	541
21	Raisen	Begamganj	Sultanganj	23.503	78.555	7.8	705	0	211	90	11	58	0.02	BDL	32	325	112	11	18	1.8	458
22	Raisen	Obaidullaganj	Sultanpur	23.136	77.932	7.99	765	0	211	120	14	13	0.25	BDL	25	200	60	12	80	2	497
23	Raisen	Obaidullaganj	Tamot	23.007	77.639	7.91	902	0	302	82	63	5	0.28	BDL	36	285	56	35	72	1.8	586
24	Raisen	Udaipura	Udaipura	23.07807	78.5098	7.5	1425	0	568	145	8	27	0.08	BDL	37	580	96	83	55	2.2	926

Annexure-3
Details of Exploratory wells in Raisen district

S. No	District	Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m^2 / day)	S
1	Raisen	Munirgarh EW	23.1994	77.6047	1979-80	42.25	42.25	Alluvium, Deccan trap basalt, Vindhyan	14-17.05	4.32	0.5		18.8	
2	Raisen	Munirgarh OW	23.1994	77.6047	1979-80	24.60	24.60	Deccan trap basalt			Negligible			
3	Raisen	Munirgarh EW-2	23.1994	77.6047	1979-80	17.82	17.82	Alluvium						
4	Raisen	Gairatganj EW	23.4094	78.3111	1979-80	191.79	191.79	Deccan trap basalt	41-42, 48.4-55.59	8.8	1.75	5.15	51	
5	Raisen	Gairatganj OW-1	23.4094	78.3111	1979-80	58.60	58.60	Deccan trap basalt	41.37-45		4.6			
6	Raisen	Gairatganj OW-2	23.4094	78.3111	1979-80	58.60	58.60	Deccan trap basalt	39-45	10.8	4.3			

S. No	District	Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m^2 / day)	S
7	Raisen	Gairatganj OW-3	23.4094	78.3111	1990-91	18.01	18.01	Deccan trap basalt			Negligible			
8	Raisen	Begamganj	23.6025	78.3494	1979-80	178.05	178.05	Deccan trap basalt	84.5-85.5, 103.5-104.5,	10.18	6.8	12.42		
9	Raisen	Obedullaganj (Ubaidullaganj)	22.9916	77.5866	1979-80	125.38	125.38	Alluvium, Deccan trap basalt, Vindhyan		24.25	Negligible			
10	Raisen	Bans Pipalia	22.9555	78.1694	1976-77	94.88	94.88	Alluvium	15.50-39.50,45.25-45.75,46.25-47.25,62.50-63.50		Negligible			
11	Raisen	Kaniwara	23.0708	78.5916	1976-77	51.60	51.60	Alluvium			12.6	9.87	24.59	

S. No	District	Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m^2 / day)	S
12	Raisen	Khargaun	23.0777	78.3022	1976-77	38.71	38.71	Alluvium,Vindhyan			Negligible			
13	Raisen	Untiakalan	22.9916	78.3541	1976-77	45.73	45.73	Alluvium,Deccan trap basalt	12-14.5,17-31.5, 33-35.5,38.25-40.50	16.55	Negligible			
14	Raisen	Sanchi	23.48278	77.7388	2000-01	30	30	Vindhyan			Negligible			

Annexure -4
Pre monsoon Water Level Data, Raisen 2021

Si No.	District	VILLAGE_NAME	Longitude	Latitude	WL May 2021
1	Raisen	Bori	78.08333	23.03056	7.67
2	Raisen	Begumganj	78.34861	23.60667	8.7
3	Raisen	Padahjir	78.40389	23.57333	9
4	Raisen	Sultanganj	78.555	23.5025	4.95
5	Raisen	Dehgaon	78.09056	23.31917	6.84
6	Raisen	Gairatganj	78.22611	23.40833	4.77
7	Raisen	Garhi	78.14222	23.39444	6.72
8	Raisen	Barkheda	77.65111	22.91667	10.32
9	Raisen	Chiklod	77.72278	23.10556	6.27
10	Raisen	Dam Dongri	77.83806	23.09944	2.92
11	Raisen	Goharganj	77.67861	23.02611	5.25
12	Raisen	Hathi palan	77.75333	23.07639	2.92
13	Raisen	Maindwa	77.54639	23.12194	1.26
14	Raisen	Sultanpur	77.93194	23.13556	3.77
15	Raisen	Tamot	77.63917	23.00667	4.45
16	Raisen	Khadera	77.94556	23.30389	7.82
17	Raisen	Kharwai	77.66333	23.26694	9.87
18	Raisen	Raisen	77.78278	23.33611	3.08
19	Raisen	Salamatpurchoraha	77.6975	23.4525	8.42
20	Raisen	Sanchi	77.74111	23.48667	5.97
21	Raisen	Dhangwan	78.47778	23.22083	10.94
22	Raisen	Siarmau	78.55	23.40083	4.45
23	Raisen	Silwani	78.43972	23.3	10.37
24	Raisen	Deori	78.68389	23.12361	7.35
25	Raisen	Khiria	78.48333	23.09222	12.23
26	Raisen	Udaipura	78.51278	23.07472	14.4

Annexure -5

Post monsoon Water Level Data, Raisen 2021

Si No	District	VILLAGE_NAME	Longitude	Latitude	WL November 2021
1	Raisen	Bori	78.08333	23.03056	5.28
2	Raisen	Begumganj	78.34861	23.60667	4.05
3	Raisen	Padahjir	78.40389	23.57333	7.65
4	Raisen	Paloha	78.29583	23.53194	8.46
5	Raisen	Sultanganj	78.555	23.5025	4.6
6	Raisen	Dehgaon	78.09056	23.31917	5.02
7	Raisen	Gairatganj	78.22611	23.40833	3.25
8	Raisen	Garhi	78.14222	23.39444	7.2
9	Raisen	Barkheda	77.65111	22.91667	6.2
10	Raisen	Chiklod	77.72278	23.10556	3.65
11	Raisen	Dam Dongri	77.83806	23.09944	1.6
12	Raisen	Goharganj	77.67861	23.02611	3.45
13	Raisen	Hathi palan	77.75333	23.07639	3.7
14	Raisen	Maindwa	77.54639	23.12194	5.1
15	Raisen	Sultanpur	77.93194	23.13556	2.55
16	Raisen	Tamot	77.63917	23.00667	2
17	Raisen	Khadera	77.94556	23.30389	3.7
18	Raisen	Kharwai	77.66333	23.26694	6.7
19	Raisen	Raisen	77.78278	23.33611	1.35
20	Raisen	Salamatpurchoraha	77.6975	23.4525	4
21	Raisen	Sanchi	77.74111	23.48667	4.15
22	Raisen	Dhangwan	78.47778	23.22083	10.9
23	Raisen	Siarmau	78.55	23.40083	2.1
24	Raisen	Silwani	78.43972	23.3	5.45
25	Raisen	Deori	78.68389	23.12361	4.93
26	Raisen	Khiria	78.48333	23.09222	7.43
27	Raisen	Udaipura	78.51278	23.07472	9.1

Annexure -6

Seasonal Water Level Fluctuation Data, Raisen 2021

Si No.	District	VILLAGE_NAME	Longitude	Latitude	Fluctuation
1	Raisen	Bori	78.08333	23.03056	2.39
2		Begumganj	78.34861	23.60667	4.65
3		Padahjir	78.40389	23.57333	1.35
4		Sultanganj	78.555	23.5025	0.35
5		Dehgaon	78.09056	23.31917	1.82
6		Gairatganj	78.22611	23.40833	1.52
7		Garhi	78.14222	23.39444	-0.48
8		Barkheda	77.65111	22.91667	4.12
9		Chiklod	77.72278	23.10556	2.62
10		Dam Dongri	77.83806	23.09944	1.32
11		Goharganj	77.67861	23.02611	1.8
12		Hathi palan	77.75333	23.07639	-0.78
13		Maindwa	77.54639	23.12194	-3.84
14		Sultanpur	77.93194	23.13556	1.22
15		Tamot	77.63917	23.00667	2.45
16		Khadera	77.94556	23.30389	4.12
17		Kharwai	77.66333	23.26694	3.17
18		Raisen	77.78278	23.33611	1.73
19		Salamatpurchoraha	77.6975	23.4525	4.42
20		Sanchi	77.74111	23.48667	1.82
21		Dhangwan	78.47778	23.22083	0.04
22		Siarmau	78.55	23.40083	2.35
23		Silwani	78.43972	23.3	4.92
24		Deori	78.68389	23.12361	2.42
25		Khiria	78.48333	23.09222	4.8
26		Udaipura	78.51278	23.07472	5.3

Annexure- 7
Location of proposed AR structures

Si No.	District	Type of Structure							
		Nala Bund/ Gully Plug		Nala Bund/ Gully Plug		Percolation Tank		Check Dam	
		Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
1	Raisen	23.02722	77.40056	23.51722	78.49111	22.97417	77.5425	23.01917	77.99083
2	Raisen	23.03222	77.37611	23.4875	78.53667	23.04333	77.55472	22.98083	77.74583
3	Raisen	23.06306	77.38833	23.50833	78.61833	23.04806	77.92278	23.21694	77.63528
4	Raisen	22.99056	77.4725	23.46194	78.57611	23.11389	77.93944	22.92778	77.53583
5	Raisen	23.01139	77.48722	23.41333	78.4625	23.08278	77.57972	23.14222	77.79528
6	Raisen	22.94083	77.48306	23.49889	78.35333	23.13556	77.84194	23.0275	77.47285
7	Raisen	22.9875	77.52472	23.45528	78.3125	23.08222	77.775	22.99278	77.67444
8	Raisen	22.99694	77.59139	23.47694	78.28222	23.03111	77.59889	22.88444	77.65333
9	Raisen	22.99083	77.57111	23.605	78.315	23.16972	77.63278	23.11778	77.6825
10	Raisen	23.09194	77.61194	23.58361	78.43639	23.22167	77.67167	23.0625	77.77694
11	Raisen	23.07806	77.62028	23.69361	78.3725	23.08	77.44361	23.01056	77.90278
12	Raisen	23.04	77.66083	23.67806	78.43944	23.00889	77.64889	23.07472	77.89222
13	Raisen	23.01111	77.67194	23.7378	78.40935	23.035	77.74417	23.01028	77.84139
14	Raisen	22.99028	77.61472	23.52389	78.64333	23.13361	77.62167	23.34833	78.57722
15	Raisen	23.03722	77.70056	23.51611	78.53528	23.04438	78.01566	23.30611	78.68917
16	Raisen	22.99639	77.71222	23.47361	78.43111	22.8501	77.62306	23.19667	78.58472
17	Raisen	22.9825	77.71556	23.51111	78.29722	23.2325	78.55278	23.25417	78.39028
18	Raisen	22.94222	77.73556	23.54028	78.25139	23.26083	78.70111	23.3075	78.26583
19	Raisen	22.91778	77.78111	23.62333	78.33306	23.21389	78.43222	23.24694	78.22611
20	Raisen	22.9975	77.78389	23.47917	78.65083	23.18444	78.40222	23.35194	78.48944
21	Raisen	23.01194	77.76306	23.43611	78.57639	23.26472	78.51111	23.28333	78.52472
22	Raisen	23.05389	77.80722	23.52833	78.69361	23.19694	78.48	23.21543	78.45139
23	Raisen	23.10444	77.83833	23.54861	78.69306	23.24889	78.28111	23.31056	78.38667
24	Raisen	23.09972	77.77583	23.60028	78.29417	23.16833	78.34333	23.32306	78.445
25	Raisen	23.16194	77.83278	23.55694	78.26806	23.17361	78.25639	23.21278	78.36889
26	Raisen	23.15139	77.84361	23.51194	78.35472	23.325	78.51667	23.20056	78.30694
27	Raisen	23.01944	77.94944	23.55417	78.45778	23.27417	78.42389	23.23472	78.64194
28	Raisen	22.98889	77.96444	23.59611	78.42528	23.18694	78.50056	23.32139	78.61528
29	Raisen	22.98556	77.99028	23.61833	78.49556	23.25278	78.62056	23.48639	78.57333
30	Raisen	23.02083	78.01694	23.46861	78.60611	23.2275	78.6125	23.53389	78.63667
31	Raisen	23.10694	77.8675	23.45056	78.56389	23.30278	78.6525	23.6225	78.41194
32	Raisen	23.11917	77.73583	23.37556	78.32083	23.21417	78.37889	23.70111	78.42861
33	Raisen	23.17639	77.6875	23.39306	78.29556	23.5425	78.28861	23.54528	78.36528
34	Raisen	23.19167	77.6325	23.46833	78.48833	23.58778	78.30917	23.56361	78.41972
35	Raisen	23.16	77.58222	23.34778	78.2725	23.63028	78.36556	23.45167	78.48
36	Raisen	23.08167	77.72806	23.36972	78.2625	23.62611	78.40167	23.56556	78.29722
37	Raisen	23.02944	77.52889	23.4	78.23722	23.545	78.4175	23.42333	78.43722
38	Raisen	23.055	77.46583	23.4275	78.24694	23.53667	78.57278	23.47333	78.19111

Si No.	District	Type of Structure							
		Nala Bund/ Gully Plug		Nala Bund/ Gully Plug		Percolation Tank		Check Dam	
		Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
39	Raisen	22.91778	77.58389	23.36083	78.18194	23.53611	78.3825	23.38	78.23417
40	Raisen	22.95306	77.59472	23.32278	78.18944	23.48111	78.46139	23.35972	78.07833
41	Raisen	22.95139	77.62028	23.29056	78.1575	23.64528	78.34806	23.30361	78.09472
42	Raisen	22.94806	77.66028	23.30083	78.11889	23.645	78.51139	23.31361	78.0375
43	Raisen	22.92528	77.7025	23.31389	78.11833	23.43298	78.42702	23.34056	77.99694
44	Raisen	22.96972	77.77694	23.33722	78.08639	23.43556	78.29222	23.52798	78.00242
45	Raisen	22.96556	77.83417	23.36889	78.07056	23.39139	78.2125	23.31917	77.84917
46	Raisen	22.99639	77.88722	23.42	78.10833	23.41194	78.05806	23.33306	77.91667
47	Raisen	23.10194	77.54639	23.49028	78.20528	23.34972	78.04222	23.41333	77.85194
48	Raisen	23.0775	77.48778	23.495	78.23778	23.43833	78.23222	23.40722	77.69583
49	Raisen	23.14222	77.68833	23.29083	78.05611	23.49667	78.27917	23.39667	77.5975
50	Raisen	23.36611	78.52694	23.39861	78.39083	23.47278	78.23056	23.45583	77.5775
51	Raisen	23.36833	78.51389	23.3825	78.36028	23.415	78.33972	23.19944	77.85972
52	Raisen	23.39	78.51917	23.43583	78.21111	23.43639	77.60278	23.25694	77.99417
53	Raisen	23.33528	78.45472	23.43389	78.1625	23.41778	77.73972	23.16194	78.73528
54	Raisen	23.30306	78.46389	23.38694	78.15167	23.34444	77.70806	23.11389	78.72222
55	Raisen	23.27361	78.47833	23.39083	78.12278	23.33	77.66722	23.11056	78.55028
56	Raisen	23.24833	78.46028	23.34639	78.12472	23.28194	77.7225	23.15028	78.33306
57	Raisen	23.22667	78.41861	23.46028	77.54889	23.30917	77.75444	23.15444	78.78389
58	Raisen	23.20472	78.36333	23.46472	77.59333	23.39472	77.95194	23.05778	78.65194
59	Raisen	23.19333	78.36472	23.42694	77.58306	23.18861	77.89417	23.10444	78.47528
60	Raisen	23.27917	78.32694	23.39639	77.61583	23.47139	77.76	-	-
61	Raisen	23.285	78.30833	23.37278	77.61194	23.29056	77.69583	-	-
62	Raisen	23.18667	78.3075	23.35083	77.65778	23.24278	77.77417	-	-
63	Raisen	23.15417	78.29167	23.375	77.67028	23.11444	78.77778	-	-
64	Raisen	23.16917	78.21917	23.34583	77.69583	23.08861	78.64278	-	-
65	Raisen	23.22806	78.185	23.35972	77.74278	23.07	78.575	-	-
66	Raisen	23.28139	78.25556	23.34389	77.735	23.03028	78.48417	-	-
67	Raisen	23.34333	78.54167	23.29778	77.84917	23.03861	78.4025	-	-
68	Raisen	23.3525	78.62	23.305	77.81889	23.12759	78.40006	-	-
69	Raisen	23.32222	78.69917	23.30861	77.8925	23.12833	78.61	-	-
70	Raisen	23.27889	78.73139	23.33056	77.89833	23.04667	78.445	-	-
71	Raisen	23.25361	78.70417	23.38417	77.91278	23.15472	78.43861	-	-
72	Raisen	23.21639	78.68639	23.38528	77.86306	23.07389	78.51417	-	-
73	Raisen	23.225	78.66	23.38778	77.84583	-	-	-	-
74	Raisen	23.21444	78.64722	23.45472	77.70028	-	-	-	-
75	Raisen	23.24667	78.55583	23.43972	77.68694	-	-	-	-
76	Raisen	23.18389	78.56444	23.28	77.94417	-	-	-	-
77	Raisen	23.18139	78.54583	23.325	77.96694	-	-	-	-
78	Raisen	23.35278	78.39028	23.22528	77.86722	-	-	-	-
79	Raisen	23.36056	78.4275	23.25556	77.82861	-	-	-	-

Si No.	District	Type of Structure							
		Nala Bund/ Gully Plug		Nala Bund/ Gully Plug		Percolation Tank		Check Dam	
		Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
80	Raisen	23.39222	78.57333	23.21083	77.76694	-	-	-	-
81	Raisen	23.30583	78.70917	23.27806	77.80222	-	-	-	-
82	Raisen	23.3775	78.59	23.33	77.83028	-	-	-	-
83	Raisen	23.25583	78.53778	23.195	77.72861	-	-	-	-
84	Raisen	23.23944	78.47361	23.21667	77.71583	-	-	-	-
85	Raisen	23.26361	78.43417	23.35528	77.91861	-	-	-	-
86	Raisen	23.30389	78.40278	23.34	77.81278	-	-	-	-
87	Raisen	23.29583	78.37806	23.47806	77.72861	-	-	-	-
88	Raisen	23.29333	78.35667	23.37889	77.70056	-	-	-	-
89	Raisen	23.33306	78.3475	23.15639	78.37583	-	-	-	-
90	Raisen	23.27333	78.3625	23.11944	78.35056	-	-	-	-
91	Raisen	23.26056	78.35528	23.13361	78.48111	-	-	-	-
92	Raisen	23.24194	78.34806	23.17833	78.73389	-	-	-	-
93	Raisen	23.23472	78.31472	23.1625	78.70528	-	-	-	-
94	Raisen	23.21639	78.26889	23.13361	78.5125	-	-	-	-
95	Raisen	23.28139	78.19861	23.09528	78.61389	-	-	-	-
96	Raisen	23.18111	78.19472	23.12944	78.72111	-	-	-	-
97	Raisen	23.1725	78.24111	23.11611	78.6375	-	-	-	-
98	Raisen	23.17611	78.28111	23.07111	78.69056	-	-	-	-
99	Raisen	23.28694	78.60472	23.09778	78.56444	-	-	-	-
100	Raisen	23.27583	78.61806	23.12833	78.55917	-	-	-	-
101	Raisen	23.36194	78.46944	23.04333	78.57278	-	-	-	-
102	Raisen	23.31389	78.43	23.16139	78.67444	-	-	-	-
103	Raisen	23.32611	78.33389	23.13111	78.46083	-	-	-	-
104	Raisen	23.25528	78.31306	23.09639	78.40972	-	-	-	-
105	Raisen	23.23472	78.26778	23.10528	78.48639	-	-	-	-
106	Raisen	23.24972	78.17361	23.20056	78.7475	-	-	-	-
107	Raisen	23.26611	78.21111	23.18444	78.78111	-	-	-	-
108	Raisen	23.34556	78.36667	23.12417	78.58917	-	-	-	-
109	Raisen	23.2025	78.55361	23.08278	78.54028	-	-	-	-
110	Raisen	23.585	78.32611	23.04167	78.43306	-	-	-	-
111	Raisen	23.54444	78.31306	23.09472	78.4325	-	-	-	-
112	Raisen	23.66889	78.32222	23.10139	78.69306	-	-	-	-
113	Raisen	23.62139	78.43944	23.07806	78.45361	-	-	-	-
114	Raisen	23.60417	78.43833	23.15944	78.65889	-	-	-	-
115	Raisen	23.59417	78.47472	23.11667	78.67389	-	-	-	-