Central Ground Water Board
Dept of WR, RD & GR
Ministry of Jal Shakti
Govt of India

NAQUIM 2.0 toolkit

- a set of operational guidelines for carrying out NAQUIM 2.0 studies

Version Beta

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Faridabad

Contents

NAQUIM 2.0 toolkit

1. Introduction

NAQUIM

The Aquifer Mapping and Management programme (NAQUIM) was launched by CGWB in the year 2012 as per the recommendations of the Report of the Steering Committee on Water Resources and Sanitation for Twelfth Five Year Plan (2012-2017), Planning Commission. NAQUIM was taken up with the objectives of delineating aquifers, characterizing aquifers and preparing aquifer management plans. National level mapping of Aquifers on 1:50,000 scale was considered sufficient for planning requirements up to block level. Some of the important uses of Aquifer mapping at 1:50,000 scale include identification of suitable areas for ground water based supply to large urban agglomerations, determine sustainability of groundwater development, identification of aquifers capable of providing water supply during protracted drought periods, prioritization of aquifers for managed aquifer recharge, identification of aquifers and determination of their suitability for various purposes in regions where new urban centres or industrial hubs are likely to come up in future, planning of integrated ground water recharge schemes, issuing advisories to the state agencies on repercussions of continued development of groundwater in select areas, recommendations to state agencies in respect of areas that have prospects for ground water development etc. Many states/UTs are using the information for planning management interventions at the block level. Out of ~33 Lakh km^2 of the entire country, a mappable area of ~25 Lakh km^2 was identified to be covered under this programme. The entire targeted area has been covered by 2022-23.

The findings of NAQUIM studies are being utilized by many agencies, especially the State government agencies involved in ground water management and water supply. Major areas where NAQUIM outputs have been used include

- Drinking water source finding and source sustainability
- Sites for Artificial Recharge
- Safe Drinking water sources in Arsenic affected areas
- Assured irrigation through ground water in areas that have adequate ground water potential.
- Implementation of water conservation and AR schemes
- Ground Water Regulation based on NAQUIM recommendation
- Rejuvenation of Hot springs
- Atal Bhujal Yojana – Participatory Ground Water Management

NAQUIM 2.0

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

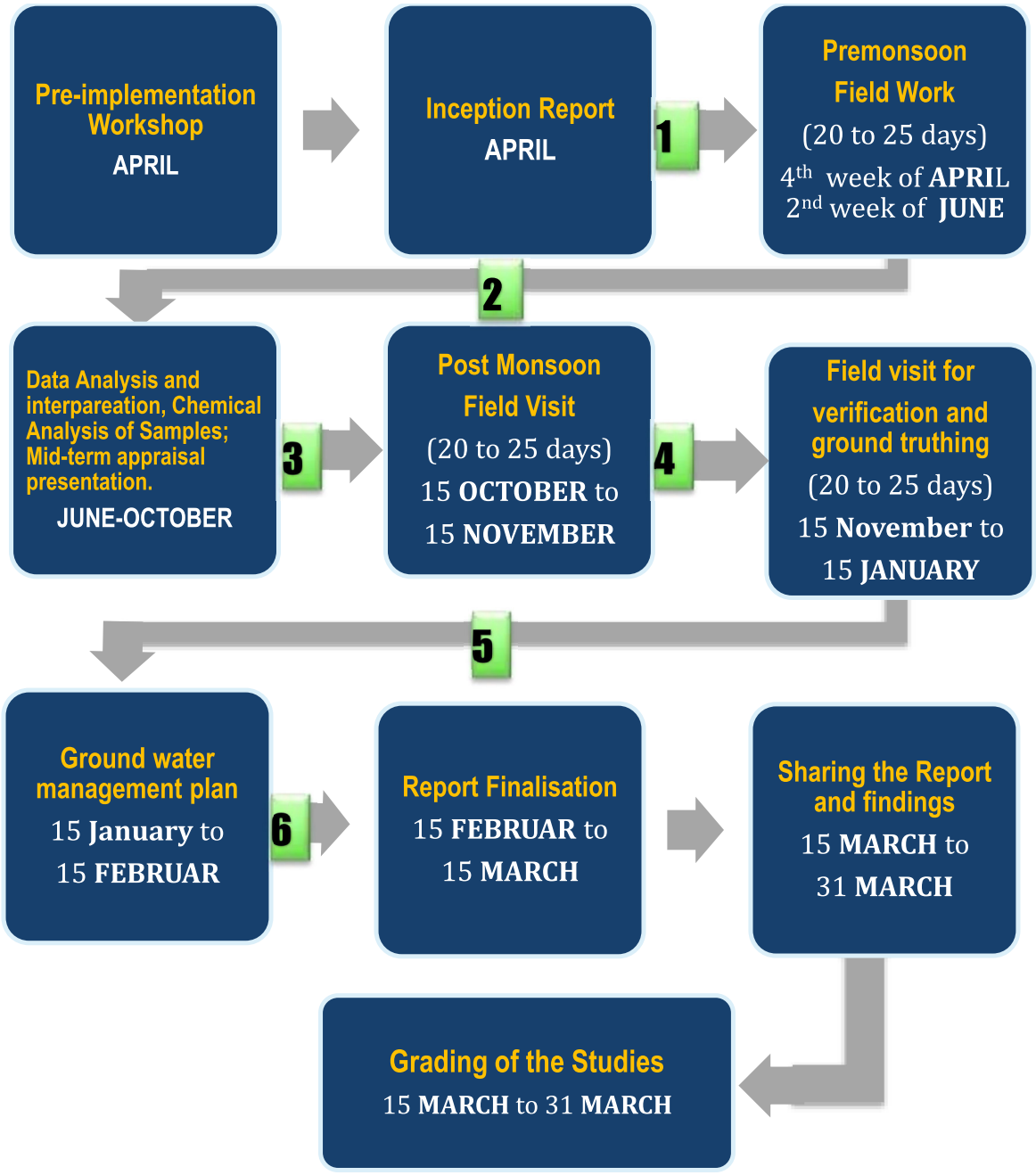
Keeping the above limitations in mind and considering the future requirements, broad objectives of NAQUIM 2.0 studies will be i) providing information in higher granularity with a focus on increasing density of dynamic data like ground water level, ground water quality etc. ii) providing issue based scientific inputs for ground water management upto Panchayat level, iii) providing printed maps to the users and iv) putting in place a strategy to ensure implementation of the recommended strategies. Involving state agencies in the studies for a sense of ownership

The Toolkit

This toolkit consists of a set of operational guidelines for the officers involved in planning and execution of NAQUIM 2.0 studies. The toolkit has been prepared after discussions with experts from various fields. The toolkit is meant to be used by trained professionals only. Detailed descriptions and exhaustive procedures are out of the purview of this document. It is expected that the professionals will use the toolkit in its true spirit.

While utmost care has been taken to provide a set of clear-cut guidelines, there is scope for improvement. The officers involved in the NAQUIM 2.0 are encouraged to use their expert judgement based on local hydrogeological knowledge. The officers involved in the studies are encouraged to carry out new analyses and follow newer approaches to achieve the goal Feedback of the team members involved in NAQUIM studies are invaluable and are welcome to improve the toolkit.

2. Calendar of Activities and Milestones



Stages of Review			
1	Inception report	**4**	Post monsoon Field work
2	Pre monsoon Field Work	**5**	Ground Water Management Plan
3	Mid-term Review	**6**	Report Writing

3. Roles and Responsibilities

The NAQUIM 2.0 studies are envisaged to be multidisciplinary. Thus, it is proposed to have a team of experts in place for carrying out the activities proposed. Each team taking up the studies will have the following composition :.

Role	Responsibilities	Indicative Designation
Team Lead	- Planning, Supervision and Execution of the Project - Work distribution and monitoring of activities of other team members - Preparation of the inception report. - Timely Delivery of the envisaged Outputs - Finalisation of the management plan - Presentations at different forums, sharing of the outputs. - Preparation of the draft report as per the approved Quality Standards and its Final Submission. - Other members of the team will assist the team lead. - Please refer the table on priority area wise deliverables and outputs for further details	Hydrogeologist
Expert (Hydrogeology)-1	- Field Data Collection (Exploration, Pz construction, Water Level, Water Quality, Pumping Tests, Infiltration tests, demand/supply data, sample surveys and others) - Sample collection for quality studies - Secondary Data collection - Entering data in database (WIMS)	Hydrogeologist
Expert (Hydrogeology)-2	- Integration of data, preparation of thematic maps, preparation cross sections etc. - Consultation with allied experts like agriculture, irrigation, agro-economics etc. - Preparation of Management Plan - Assisting the Team Lead in preparing maps and reports. - All Officers should work in GIS and try to prepare maps on their own. - Please refer the table on priority area wise deliverables and outputs for further details	Hydrogeologist
Expert (Geophysics)	- Field Geophysical Surveys - Interpretation of field data - Entering data in database (WIMS) - Integration with existing geophysical and lithology data - Preparation of inferred lithologs - Suggesting potential sites for construction of water wells/artificial recharge - Preparation of Tables, graphs and maps for reports - Assisting the Team Lead in preparing the Report - Please refer the table on priority area wise deliverables and outputs for further details	Geophysicist
Expert (Hydro chemistry)	- Sample collection for quality studies - Analysis of samples. - Integration with existing data - Validation and interpretation of data - Entering data in database (WIMS) - Preparation of Tables, graphs and maps for reports - Assisting the Team Lead in preparing the reports - Please refer the table on priority area wise deliverables and outputs for further details	Chemist

4. Prioritisation of Areas

NAQUIM 2.0 is designed to provide detailed information to support groundwater management decisions at ground level. Since the issues are different in different areas, the studies under NAQUIM 2.0 are proposed as issue specific and will be undertaken in prioritized focus areas. Broadly 11 Priority areas are identified based on ground water related issues as given below.

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

5. Work Plan and timelines

Period	Assignments to be carried out
1st to 3rd week of April	**Base map Preparation:** - Area map showing communication network, drainage, important places, existing NHS, existing EW, OW, Pz &DW, Data generated during previous NAQUIM studies and proposed locations for establishment of key wells - The RF (Reduction Factor or Representative Fraction) of the admin basemap should be 1:10,000 or more. **Preparation of the Inception Report:** - Please see the format for details.
I_{st} Review	Review of Inception report
4th week of April 2nd week of June **(20-25 days fieldwork)**	**Field Data Collection** - Key well/spring establishment; Water level/spring discharge measurement including geo-coded locations (if not done earlier). & Water sample collection - Density of one key well per 5 - 10 Km^2, collect aquifer wise data wherever possible. Rigorous monitoring of deeper aquifer is necessary if they are commonly being used for agriculture & Industrial purposes. If they are less frequently used, coarser sampling and monitoring is considered sufficient. - Specific studies -Infiltration, Slug test, Pumping test - Apprising Block level Authorities about the Work Item. Presentation of Inception Report. **Sample Surveys and User Feedback:** - Discussions with farmers and other users at ground level. Collection of information from local agencies or well owners about well depth, slotted zone/fracture zone, discharge (can be measured by the officer,if possible), static water level and random drawdown data, Irrigation Practices, cropping pattern and related information. - Instantaneous discharge measurements along with data on, pump working hour for estimating unit draft. - A sample feedback form is annexed.

Period	Assignments to be carried out
	Other ongoing field activities - Exploratory drilling, geophysical studies, data entry in WIMS
II_{nd} Review	Premonsoon Field Work
15th June to 15 October	**Data Analysis and Interpretation** - Compilation & analysis of data collected during pre-monsoon field work - Completion of chemical analysis of samples collected and data validation - Preparation of thematic maps such as pre-monsoon DTW, EC, Cl maps and identification of areas with quantity (deeper water level, declining trend, drying of wells/reduction of discharge) & Quality issues (F, NO_3, Fe, As) - Preparation of Location, LULC, Physiography & drainage, DEM, Hydrogeomorphic, Basin, rainfall histogram, Geological maps etc - Preparation of relevant chapters on the themes like Introduction, Physiography &drainage, Hydrometeorology, Hydrology, Landuse Landcover, Geology etc. - Tabulation and correlation of hydrogeological and geophysical data of existing EW, OW, PZ & DW, VES, TEM - Preparation of Cross sections (2D) showing aquifer disposition by correlating lithologs. - Conceptual 3D Model (which will be modified after getting more data during post-monsoon studies) - Analysis of lithologs and aquifer properties data of previous studies and their incorporation - Mapping of water bodies from Satellite Imagery and its comparison with toposheet for preparation of RWH & AR Plan - Collection of drilling & other related data from State Govt agencies, Drilling companies & NGOs **Workshops and mid-term review by NLEC** - Regional Workshops of officers involved in NAQUIM 2.0 studies to exchange experiences, field data collection strategies, new findings etc. - Mid-term review and guidance by the NLEC. - Communication and/or Presentation (preferably) before District Administrative Authorities
III_{rd} Review	Mid-term Review
15th October to 15th December (**20 to 25 days field work**)	**Field Data Collection** - Post-monsoon water level monitoring - Monitoring of additional wells in areas identified with some issues based on level & quality monitoring data of pre-monsoon - Conducting pumping tests at field in irrigation wells, discharge vs drawdown measurement, quality checking with hand-held EC & pH meter, collection of drilling data from the pump/land owner etc. **Sample Surveys and User Feedback:** - Discussion with farmers and other users at ground level. Collection of information from local agencies or well owners about well depth, slotted zone/fracture zone, discharge (monitored wherever possible), static water level and random drawdown data, Irrigation Practices,

Period	Assignments to be carried out
	cropping pattern, traditional water conservation and management practices and related information. - Instantaneous discharge measurements, along with pump working hour information for estimating unit draft. - Similarly, feedback of the local users will form an important input for problem identification and characterization. Feedback are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. - A sample feedback form is annexed, which can be customized to the type of priority area and objective of the study. **Other ongoing field activities** - Exploratory drilling, geophysical studies, data entry in WIMS
IV_{th} Review	Post monsoon Field work
15th December to 15th January	**Data Analysis and Draft Report Preparation** - Compilation & Analysis of Post-monsoon data (Statistical analysis based on geology, physiography, etc. can also be attempted) - Chemical Analysis of the post monsoon water samples (collected from selected wells for confirmation of issues) - Preparation of maps and tables- please refer priority area wise deliverables and outputs - Preparation of ground water management plan, analysis of existing practices and proposed measures under Supply side and Demand side measures with the expected impact on ground water system. - Draft Report writing work **Other ongoing field activities** - Exploratory drilling, geophysical studies, data entry in WIMS
V_{th} Review	Ground Water Management Plan
15th January to 15th February (**20 to 25 days 2fieldwork**)	- Field truthing of Management plan & RWH & AR Plan - Final Stage field visit for various field data collection & generation based on the requirement (data gap filling) as observed during draft report preparation **Other ongoing field activities** - Exploratory drilling, geophysical studies, data entry in WIMS
VI_{th} Review	Report
15th February to 15th March	- Modification of draft report with additional information collected by the above mentioned field checks - Scrutiny and Finalisation of the Report **Other ongoing field activities** - Exploratory drilling, geophysical studies, data entry in WIMS
15th to 31st March	- Sharing of the reports with CHQ, SGWCC and DM/DC - Brochure to be prepared by 31st March. **Other ongoing field activities** - Exploratory drilling, geophysical studies, data entry in WIMS

Maps in 1:50,000 scale to be printed by 30th April. 60 to 75 days of field work is required for generating sufficient data in desired granularity for a study area varying from 300 to 800 Km^2 depending on the extent of hilly areas, urban & industrial agglomerations, mining areas etc. Being a tentative program, it can be modified based on the onset of monsoon and other factors . If possible, basecamp may be established in the administrative HQ or adjacent urban area . In case of manpower shortage, field officers can also be mobilized from other regions to cover more areas under the time frame. Major contributions of the officers are to be clearly mentioned in the report rather than repeating their name in every item of work. Six review meetings are proposed after completion of major tasks.

Regional Director/Member to assess the periodic achievements and suggest the course corrections if required. As specified in the previous section, such reviews will be done for every milestone (1. Inception report, 2. Premonsoon Field Work 3. Mid term Review 4. Postmonsoon Field work 5. Ground Water Management Plan and 6. Report Writing). An indicative proforma is annexed for review and verification of progress of activities.

6. Data Density

Data element	Indicative Density
Exploratory Drilling	After studying the Exploratory well density in the study area, new wells may be proposed based on the Exploratory well target. Exploratory drilling may be taken up in between two existing wells to validate the earlier analysis/profile/section. At least two for each principal aquifer type in the area
Pumping Test	At least one for each principal aquifer type in the area
Water Level	At least 3 water level per each aquifer (depth wise) for each GMU (Ground Water Management Unit) or 1 for every 10 sq. km, whichever is higher. A GMU could be a village, a ward, aquifer unit, geomorphology, LULC class or as relevant to the study. Deeper aquifers if available are to be treated as separate GMUs.
Water Quality	At least 3 sample per each Aquifer (depth wise) for each GMU or 1 for every 10 sq km, whichever is higher. At least one for each habitation in areas with ground water contamination.
VES/TEM/Imaging	At least 05 for each principal aquifer type in the area
Feedback and Sample survey	At least 1for each village. OR At least 3 for each GMU (aquifer type or land use as relevant to the study).

7. Priority Area wise deliverables

S.No	Deliverables	1	2	3	4	5	6	7	8	9	10	11
1	Aquifer Dispositions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Aquifer-wise ground water Water Levels	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Delineation of Recharge Areas	✓	✓	✓	✓	✓	✓		✓		✓	✓
4	Estimation/Refinement of parameters used for resource assessment	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
5	Assessment of ground water resources	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
6	Location, Discharge and water quality of the springs, vulnerability of the springs					✓						
7	Demarcation of the springshed					✓						
8	Ground Water Quality in every habitation							✓				
9	Ground Water Quality	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10	Areas showing signs of subsidence	✓	✓	✓			✓					
11	Extents of autoflow zones								✓			
12	Extent of saline ingress			✓								
13	Ground Water Quality Management Interventions including demarcation of safer aquifers	✓	✓	✓	✓			✓		✓	✓	
14	Impact of Mining or Industrial activities and vulnerability of the aquifers.				✓							
15	Artificial Recharge Plan	✓	✓	✓	✓		✓				✓	
16	Other measures	✓	✓	✓	✓		✓				✓	
17	Identification of potential aquifers for drinking water supply	✓	✓	✓	✓	✓		✓		✓	✓	
18	A plan for drinking water source sustainability	✓	✓	✓	✓			✓			✓	
19	Identification of potential aquifers for Irrigation			✓		✓	✓	✓	✓	✓		
20	Recommended interventions for containing saline ingress (Artificial Recharge, Regulation etc.)			✓								
21	Potential aquifers that can be used for carbon sequestration			✓			✓					
22	Recommendations for springshed management					✓						
23	Recommendations for spring water harvesting					✓						
24	Potential to be used as rainy-day resource.						✓					
25	Ways to minimise ground water losses because of free flowing wells.								✓			
26	Plan for Conjunctive use of surface water and ground water									✓		
27	Recommendations for tackling water logging		✓									
28	Demand driven studies like- Source Finding, Development of new cities, Waste disposal sites etc.											✓

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

*[Estimation of Unit draft to be carried out in each studies indicated above. Estimation of Recharge parameters to be restricted to all Conjunctive Use studies and any one Study each year for each Region. Such studies would be of 2 years duration]

8. Deliverable wise details

S.No	Deliverables	Inputs	Data Processing	Outputs
1	Aquifer Disposition	- Exploratory Drilling - Geophysical Studies. - Pumping Tests - Aquifer wise ground water quality analysis - Field exposures, well sections etc. - Aquifer wise water levels. - Farmer feedback	- All data to be entered in WIMS - Aquifer delineation by correlating Litholog, inferred logs from geophysical surveys, feedbacks, aquifer property, water quality. - Using all the above data for preparation of a 3D hydrogeological model. Modeling software like Rockworks can be used. - Hand drawn sections and block diagrams can also be included.	1. GIS based point map of aquifer disposition with following attributes Aquiferwise: Depth To Aquifer Top, Depth To Aquifer Bottom, Thickness, Potential Zone from, Potential Zone to Discharge (lps), T, S, Sy, Quality, 2. Aquifer information derived from Geophysical Study based inferred lithologs: Depth To Aquifer Top, Depth To Aquifer Bottom, Thickness, Potential Zone from, Potential Zone to Quality (Fresh/Saline). 3. 3D model -Cross Sections/Block diagrams. In Rockworks format and images.
2	Aquifer-wise ground water Water Levels	- Observed water levels including historical data. - R L of monitoring Stations - DEM	- All data to be entered in WIMS - Statistical analysis of water levels including timeseries analysis - GIS based data processing. - Use standard contouring methods. - Use constraints based on field observations, geomorphology for manual refinement of the contours. - Long-term Water Level Trends (longest available).	1. Aquifer-wise depth to water level maps (heat maps) 2. Aquifer-wise Contours of water table/ piezometric surface elevations and flow lines 3. Map showing water level trends 4. Representative hydrographs with trends 5. Area showing long-term water level changes.

S.No	Deliverables	Inputs	Data Processing	Outputs
3	Delineation of Recharge Areas	- Aquifer-wise Contours of water table - DEM (SRTM, ASTER) - R L Survey data - Toposheet, Google Map, Satellite Data (TM-7/8 or LISS-III) for drainage& water body mapping - Isotope Data - Land use	- Recharge areas are to be identified by integrating Surface elevation, Water table Contours, Flow lines, Aquifer types, Land use, water bodies, isotope data etc.	1. A map showing major recharge areas. If recharge area is outside the area of study, it also has to be shown.
4	Estimation/Refinement of parameters used for resource assessment	- All related field data, historical data as well as farmer feedbacks.	- Sample surveys for unit draft. - Infiltration studies for RIF - Chloride Mass balance for RIF estimate - Tritium injection studies for recharge rate - Pumping tests and dry season water balance for Sy - Pumping tests and slug tests for recharge rate from recharge wells. - Drum Culture for Recharge from Return flow from Irrigation - Study on recharge from water conservation structures. - Study on recharge from ponds, lakes flood plain areas. - Other standard methods as per the GEC 97 methodology or published literature may be used.	1. Maps and tables showing aquifer wise parameters. To be integrated with the aquifer disposition maps and tables.
5	Assessment of ground water resources	- All related data as per GEC. - Seasonal water table and piezometric surfaces measurements.	- Use the GEC methodologies- adapt the methodology to the study area scale and provide all details as per the methodology.	1. Regions (Ground Water Management Units) with attributes – recharge/discharge parameters,

S.No	Deliverables	Inputs	Data Processing	Outputs
		- Transmissivities	- May use any new criterion based on site specific issues. - Use Q=TIL to calculate flow across boundaries	categorisation as per the GEC methodology. 2. The GMUs could be the aquifers, villages or other units. The Deeper aquifer can be treated as a separate GMU. 3. Seasonal inflow/outflow across the boundary to be shown on table along with a map.(The boundary may be split into a few section, as relevant to the study area-similar to what is done in a Modeling exercise)
6	Location, Discharge and water quality of the springs, vulnerability of the springs	- Historical data - Measurement of discharge & temperature - Quality of spring water quality	Statistical and spatial analysis of data	1. GIS based map of spring locations with the relevant attributes. 2. Identification of vulnerable springs.
7	Demarcation of the springshed	- Global datasets - Reduced Level Surveys - Spring discharges - Isotope studies	Spatial analysis of data	1. GIS based map
8	Ground Water Quality in every habitation	- Historical data, published literature - Collection and analysis of samples from every habitation	Statistical and spatial analysis of data	1. Geotagged locations of the sampling points, type of structure, probable depth, type of aquifer (mention aquifer number/ mixed aquifer.) 2. Sampling location details so that repeat sampling, if required can be carried out. 3. Parameter wise concentrations in the relevant units. 4. GIS based maps, Point maps with the concentration as attribute.

S.No	Deliverables	Inputs	Data Processing	Outputs
				5. Contouring wherever continuity is expected. 6. Description on probable sources and release mechanism 7. Ground Water Quality Hotspots
9	Ground Water Quality	- Historical data, published literature, analysis of samples of the ongoing study - (geogenic, man-made and pathogens) - Aquifer map with attributes - Land use map - Soil map - Thickness of weathered zone map - Other area specific activities (waste disposal, use of treated waste water) and their impact	- Statistical, spatial and time series Analysis - Hydrochemical diagrams. Variation diagrams - Multi-variate statistical analysis like Principal Component Analysis. - Index overlays (may be DRASTIC). Correlation with aquifer type, land use etc.	1. GIS based maps, Point maps with the concentration as attribute. 2. Contouring wherever continuity is expected. 3. Description on probable sources and release mechanism 4. Vulnerability Map. 5. Ground Water Quality Hotspots 6. Impact of waste disposal sites 7. Impact of use of treated wastewater 8. Solute transport modeling in selected areas.
10	Areas showing signs of subsidence	- Published literature - SAR data - Signs of subsidence observed in field	- Analysis of Satellite data with published literature and field observations	1. Map showing zones of subsidence with relevant attributes.
11	Extents of autoflow zones	- Water Levels/ Piezometric heads - Feedback - Global datasets (SRTM, ASTER) - R L Field Survey	- Statistical Analysis, time series analysis and spatial analysis	1. Map showing areal extent of the autoflow zones
12	Extent of saline ingress	- Historical and current data of ground water quality - Water Levels	- Statistical Analysis, time series analysis and spatial analysis	1. Map showing extent of saline intrusion

S.No	Deliverables	Inputs	Data Processing	Outputs
		- Feedback - Global datasets (SRTM, ASTER) - R L Field Survey	- Hydrochemical facies –on map to identify if there is progressive salinisation or freshening.	2. Map showing migration of coastline (if available) 3. Map of hydrochemical facies 4. Zones of subterranean ground water discharge 5. Volume of water going to the sea (or entering into)
13	Ground Water Quality Management Interventions including demarcation of safer aquifers	- Aquifers - Water Levels - Ground Water Quality - Land use - Vulnerability map - Temporal variations - Sources of contaminants - Recharge Areas	- Delineate the safer aquifers - Analysis of recharge areas - Relation of quality issues with land use, aquifers, rainfall etc. -	1. Map of alternate safe aquifers, if available 2. Recommend measures for well-head protection 3. Recommend sites for waste disposal or changing sites of waste disposal 4. Recommendations regarding use of treated wastewater etc. 5. If well heads (or the recharge areas) are away from the wells they are to be shown on map 6. Locations and Designs of recommended structures
14	Impact of Mining or Industrial activities and vulnerability of the aquifers.	- Information about the mines or the industry - Aquifer geometry - Ground Water levels - Ground Water Quality - Flow lines and flow directions	- Statistical Analysis, time series analysis and spatial analysis	GW Abstraction by Industries, Water accumulation and Dewatering in Mining pits, Corresponding changes of GW storage Declining water level, deteriorating quality etc. Areas are to be shown on map.
15	Artificial Recharge Plan	- Analysis of SRTM, Toposheet, Satellite Data (TM-7/8 or LISS-III) & Google Map - m2/day	**Soft rock Areas** - Post Monsoon Pz head level>10mbgl& T or Sp. Capacity*>100 m2/day	1. Feasible areas are to be shown on GIS based maps with explanatory notes using the thematic layers of Geology, Geomorphology, Landuse/Land cover,

S.No	Deliverables	Inputs	Data Processing	Outputs
			Hard rock Areas Post Monsoon Pz head level >10mbgl& T or Sp. Capacity >20 Location finalisation based on DEM, Satellite Imagery, Toposheet, Panchayat Cadastral Map, Maps showing sustainability of aquifers for irrigation and drinking water State agencies can also be involved in preparation of Artificial Recharge Plans.	Lineaments, Structures, water levels during post monsoon. Declining trends of ground water and available surplus runoff. 2. Areas recommended for construction of AR structures in shallow aquifers; 3. Areas recommended for construction of AR structures in deeper aquifers; Recommended depths of structures; Locations and Designs of recommended structures
16	Other measures	- (demand side measures): crop diversification, micro-irrigation, regulation etc.	Agriculture & Irrigation data and Map of State Agencies LISS-III/ LISS IV Imagery Interpretation for Mapping of Rabbi Crop areas Field truthing to validate the map	1. Feasible areas are to be shown on GIS based maps, Tables with indicative estimates and description 2. Map based calculation of requirement of water for those crops classified. Based on the availability of all water resources, demand size management can be planned.
17	Identification of potential aquifers for drinking water supply	- Aquifer geometry - Aquifer Properties - Farmer Feedback - Geophysical Studies - Ground Water Quality	Already mentioned in Sections and 3DMap Map showing areas with assured water supply, irregular water supply & no water supply system. Management Plan for assured water supply (potential aquifer, probable yield & sustainability)	1. GIS based maps showing extent, depth, thickness and relevant properties of the aquifers as worked out earlier. Description. **2.** Potential sites for drilling wells from geophysical studies

S.No	Deliverables	Inputs	Data Processing	Outputs
18	A plan for drinking water source sustainability	Refer the Source Sustainability SoP.		1. Maps showing location of proposed interventions and description.
19	Identification of potential aquifers for Irrigation	- Resource Assessment Results - Yield of aquifers - Drawdown - Water Levels	**Hard rock area** **Sustainable:** Shallow fractures (within 75 m), Yield >3lps, Post-monsoon dtwl< 10 mbgl, drawdown (DD) within 10 m **Moderate sustainability:** Shallow fractures with Yield between 1-3lps& Deeper fractures (beyond 75 m of depth) with Yield >3lps. Post-monsoon dtwl< 10 mbgl, DD <10 m for both the aquifers **Poor Sustainability:** Shallow fractures with Yield <1 lps& Deeper fractures with yield between 1-2 lps. Post-monsoon dtwl> 10 mbgl, DD > 20 m for both the aquifers **Soft rock area** **Sustainable:** Yield >10 lps, Post-monsoon dtwl< 10 mbgl, DD within 10 m **Moderate sustainability:** Yield between 5-10 lps, Post-monsoon dtwl< 10 mbgl, DD within 10 m &Yield > 10 lps. Post-monsoon dtwl between 10 - 20 mbgl, DD > 10 m **Poor Sustainability:** yield between 1-5 lps. Post-monsoon dtwl> 10 mbgl, DD > 10 m	1. Maps showing areas suitable for shallow & deeper aquifers for further ground water development (extent, depth, thickness and relevant properties can be mentioned) **2.** Potential sites for drilling wells (points to be provided based on geophysical studies) with details
20	Recommended interventions for	- Map showing extent of saline intrusion	- Spatial analysis and integration of the data.	1. GIS based maps with relevant attributes. The Information are

S.No	Deliverables	Inputs	Data Processing	Outputs
	containing saline ingress (Artificial Recharge, Regulation etc.)	- Map showing migration of coastline (if available) - Map of hydrochemical facies - Zones of subterranean ground water discharge - Volume of water going to the sea (or entering into) - Recharge and draft components		also to be provided in a table along with description 2. GIS based map of feasible areas for other types of interventions. 3. GIS based map showing locations and design of structures
21	Potential aquifers that can be used for carbon sequestration	- Aquifer geometry - Aquifer properties	- Please refer standard literature	1. GIS based maps (extent, depth, nature and thickness of the confining layer, Aquifer properties etc.)
22	Recommendations for springshed management	- GIS based map of spring locations with the relevant attributes. - Vulnerable springs. - Spring discharge and quality	- Statistical Analysis, time series analysis and spatial analysis	1. GIS based maps with explanatory notes Locations and Designs of recommended structures
23	Recommendations for spring water harvesting	- GIS based map of spring locations with the relevant attributes. - Vulnerable springs. - Spring discharge and quality	- Statistical Analysis, time series analysis and spatial analysis	1. Location and design of the structures to be shown on a GIS based map. 2. Locations and Designs of recommended structures
24	Potential to be used as rainy-day resource.	- Aquifer geometry - Aquifer properties	- Analysis of sustainability of the aquifers - Analysis of Techno-economic feasibility of construction of wells	1. GIS based maps (extent, depth, Aquifer properties etc., sustainability, Recharge areas etc.)
25	Ways to minimise ground water losses because of free flowing wells.	- Inventory of auto flowing wells	- Analysis of temporal and spatial variation in discharge, quality - Water budgeting based on GEC methodology	1. Recommendations with map showing areas where such recommendations can be implemented.

S.No	Deliverables	Inputs	Data Processing	Outputs
		- Seasonal Flowing discharge (pre, post) and quality (pre monsoon) - Historical data on discharge, quality Aquifer properties		2. Recommendation on well design including mechanism for regulated discharge of auto-flowing wells
26	Plan for Conjunctive use of surface water and ground water	- Map of command area - Extended influence area of the Command - Ground Water Quality - Details of canal - Volumetric input of surface water and ground water in the command area - Cropping pattern -	Water budgeting based on GEC methodology	1. Must include a GIS map showing locations of the interventions. 2. Tabular statements of conjuctive use plan
27	Recommendations for tackling water logging	- Aquifer geometry, properties and chemistry. - Water Levels - Satellite data - Ground water as well as surface water chemistry	- Statistical Analysis, time series analysis and spatial analysis	1. Map of waterlogged areas 2. Map showing areas prone to water logging 3. Feasibility of artificial recharge or 4. Vertical drainage interventions
28	Demand driven studies like- Source Finding, Development of new cities, Waste disposal sites etc.	- As per the study requirement	- As per the study requirement	1. Case specific outputs with maps

9. Forms of outputs

Detailed information for water professionals and researchers	Planners, Administrators	Grassroots level users
- All the raw data is to be entered in WIMS. - The GIS maps (.shp or .tab files) as per the deliverables - All maps to be congruous with adjoining boundaries. - are to be shared with NWIC. - Detailed Reports	- Printed maps (as per the deliverables) on 1:50,000 scale. - Brief recommendations - Presentations - Detailed Report	- Brochures in English/Hindi or local language

10. Guidelines for Quality Control

The core objective of NAQUIM 2.0 is to present implementable groundwater management plans and strategies to the user agencies. Therefore, there is a requirement for Quality control of the studies undertaken in NAQUIM 2.0. A five pronged strategy is proposed to ensure quality of the studies.

SoP	Pre Implementation Workshop	Inception Reports	Mid-term review	Grading of the studies
• An SoP is required to be prepared and distributed. • The SoP needs periodic revision based on feedback from field officers	• A training workshop shall be organized in the month of April, preferably at RGI • It will include presentation by experts, as well as presentations on representative studies of previous years. • Discussion on the SoPs • States can also be invited for the workshops	• An inception report with detailed work plan must be prepared before taking up the study	• Mid-term workshop on NAQUIM , to be organized by a group of Regions / individual Regions • Objective, plan of execution and interim results/findings of each study to be presented in the Workshop • The work shall be reviewed by experts and course corrections suggested, if required • NLEC or similar expert Committees to be constituted, if necessary	• Innovative studies to be tagged with 'Star' (*) • Tagging to be done by the Expert team (given in footnote) ○ Tagging to be reviewed and approved by NLEC or similar expert committee and Show cased as 'NAQUIM 2.0 SUCCESS STORY'

NB: Experts team of 3/5 persons consisting – Member (In-charge of Region) or his nominee Senior Officer CHQ; Retired CGWB/State Officers, Academician/Researchers and Regional Director

Annexure -I

Inception Report Format

- About the study area
- Priority types
- Previous Studies- NAQUIM reports, District Brochure, Resource Assessment Report, Reappraisal Report, Systematic Survey Report, Published papers, New paper articles etc.
- Objectives of the present study
- Existing data- EW/OW, VES/TEM, WL (NHS and Aquifer Mapping), WQ, Infiltration Test, Pumping Tests.
- Data gap analysis
- New Data generation plan- Activity wise monthly targets for new data generation. Plan for integration with other ongoing activities.
- Month-wise activity plan – field visits, visits to local offices, training, report writing, sharing with the concerned departments, entering data in WIMS, Progress Reporting in MIS, uploading reports and media in publications warehouse.
- Composition of the team.
- Team-member-wise responsibilities and monthly targets for entering in the MIS

Annexure -II

Final Report Format

- Introduction
- About the study area (geography, geomorphology, rainfall, land use, irrigation, crops etc.)
- Priority types
- Previous Studies- NAQUIM reports, District Brochure, Resource Assessment Report, Reappraisal Report, Systematic Survey Report, Published papers, New paper articles etc.
- Objectives of the present study
- Each deliverable will be a chapter with the following structure
    - Objective
    - Material and methods
    - Results and Discussions
- Any other chapter as per the study specific requirement
- Conclusions and recommendations
- Supplementary Material(Annexure):
    - All raw datasets (Water level, water quality, VES, TEM, Pumping Tests, Statistical Data)
    - Copies of feedback of the farmers obtained from the field

Annexure -III

Farmer Feedback Form

Photograph			
Name			
Village			
Block			
District			
Address			
Mobile Number (optional)			
Type and number of structures			
Type			
Number			
(coordinates of the structures are to be obtained by the field officer)			
Drill time discharge (lps)			
Depth of installation of pump			
Casing depth (Bore wells) HR			
Fracture encountered depth-HR			
Slotted pipe depths (TW) SR			
Average water levels – pre-monsoon			
Average water levels – post-monsoon			
The well is used for			
Is water available throughout the year			
If not for how many months water is available			
Pumping Duration			
	Number of days pump is operated (days) of each well	What is the average pumping duration (in hours) of each well	Instantaneous Discharge Measurement (to be carried out by the field officer) in lps
Rabi (no of months to be specified)			

Kharif (no of months to be specified)			
Others (no of months to be specified)			
Area Irrigated			
	Area Irrigated	Type of crop taken	Remarks
Rabi (no of months to be specified)			
Khariff (no of months to be specified)			
Others (no of months to be specified)			
Cropping patterns (past and present) in the village			
Traditional Cropping pattern in the village	Kharif	Rabi	Other
Type of Crop			
Area under crop			
Prevailing Cropping pattern in the village	Kharif	Rabi	Other
Type of Crop			
Area under crop			
Reasons for change in cropping pattern in last 20 years.			
If the cropping pattern is to be changed, which are the suitable crops that can be grown			
Available Market for the crop			
Average unit cost of production			
Average unit cost of selling			
Existing MSP and other related information	Crop wise details are to be collected		
Other subsidies, facilities, restrictions.			
Source of Energy			
Solar	○ Is it connected to grid ○ If yes how much incentive do you get per month on an average for feeding electricity to the grid (Rs per month)		
Electric	○ Do you get free electricity for irrigation? ○ Do you pay a fixed charge ○ If a fixed charge is paid, what is the per month charge ○ If unit-based charges are paid what is the average monthly charges in rupees ○ During kharif---- ○ During Rabi-----		
Diesel	○ Average consumption of diesel (liters) per month ○ During Kharif ○ During Rabi		

Water Market*	○ Do you share the pumped water with other farmers ○ If yes ○ For how many days do you share pumped water in Kharif ○ For how many days do you share pumped water in Rabi Period ○ On an average how much do you charge per annum (in Rs)
	○ Do you receive additional water from boreholes of nearby farmers ○ If yes ○ For how many days do you receive pumped water in Kharif ○ For how many days do you receive pumped water in Rabi Period ○ On an average how much do you pay per annum (in Rs)
Other issues/Remarks	e.g. common problems in drilling of wells, common health issues in the area etc

- Feedback of the local users will form an important input for problem identification and characterization. Feedbacks are to be obtained in case of Urban areas, Industrial clusters also. Feedbacks on drinking water availability, dependence on ground water etc are also to be obtained. The above feedback form can be customized to the type of priority area and objective of the study.

Annexure -IV

Periodic review of activities

Study Area: sq.km, block, district, state etc.
Priority Types:
Team Lead:
Team Members (HG, CH, GP and others)

Sr. No.	Activity	Progress report to be updated on a monthly basis for review by Team lead /Regional Director/Member
1	Inception report	Submitted (Y/N) Date of submission
2	Field Work- I (Premonsoon)	Officer wise field days Officer Name : No of field days (from to)
3.	Apprising Block level and District level Authorities	Y/N Meeting / Presentation
3	Field Work – II (Post monsoon)	Officer wise field days Officer Name : No of field days (from to)
4	Field Work- III (Dec-Jan)	Officer wise field days Officer Name : No of field days (from to)
5	Existing data -EW/ OW/ Water Level /Quality/VES/TEM etc.	Collection of data and entering in WIMS
6	New EW/OW/PZ drilled	Numbers drilled EW/OW data entered in WIMS
7	Pumping Tests carried out	Numbers and duration of pumping
8	Studies for estimation of parameters used in resource assessment	Please specify
9	Number of water level /spring discharge data (pre-monsoon)	Aquifer I: ; Aquifer II: ; Aquifer III:; Water Level Data entered in WIMS (Y/N)
10	RL survey of wells done	Numbers
11	Number of water data /spring discharge (post monsoon)	Aquifer I: ; Aquifer II: ; Aquifer III:; Water Level Data entered in WIMS (Y/N)
12	Number of samples collected (pre-monsoon)	Aquifer I: ; Aquifer II: ; Aquifer III:;
13	Number of samples collected (post-monsoon)	Aquifer I: ; Aquifer II: ; Aquifer III:;
14	Number of samples analysed	Aquifer I: ; Aquifer II: ; Aquifer III:; Results entered in WIMS
15	Number of VES/ TEM/Imaging	Number of studies carried out; Results entered in WIMS
16	Number of sample surveys done	Numbers
17	Mid-term appraisals done	Number, dates and other details
18	Other field studies done	Please specify
19	Outputs as per the deliverables	Deliverables completed Number of GIS based maps prepared.
20	Final Report	Submitted and uploaded in website
21	Sharing of report	Presentation before DM/DC

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