



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

**Process Flow and Standard Operating Procedures
for Activities under
National Aquifer Mapping and Management (NAQUIM)
Programme**

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(previous version: 1 - March 2021)

**CGWB, Bhujal Bhawan,
Faridabad March 2021**

Preamble

What is NAQUIM?

National Aquifer Mapping Programme(NAQUIM) was initiated by Central Ground Water Board, Ministry of Jal Shakti, Government of India with a vision to identify and map the aquifers with their characteristics, to quantify the available groundwater resources, propose plans appropriate to the scale of demand and supply in order to formulate a viable strategy for the sustainable development and management of ground water resources.

What is an SOP?

A Standard Operating Procedure (SOP) is a brief, easy-to-understand and use document comprising step-by-step instructions, action points and workflows of different operations. An SOP usually provides clear-cut directions as to how employees within the organization must go about completing certain processes.

Why is an SOP important?

Standard operating procedure documentation is important because it allows organizations to systematize their processes, keep all team members and other stakeholders on the same page at all times, and move forward in a well-defined, cohesive manner.

SOPs aim to achieve efficiency, quality output and uniformity, while reducing miscommunication and failure to comply with organization regulations. SOPs can also provide employees with a reference to common practices, activities, or tasks.

This document contains the work process flow and standard operating procedures for the following major activities of CGWB under NAQUIM programme.

1. Aquifer Mapping and development of Management plans
2. Site Selection for Exploratory Drilling
3. Geophysical Survey- Vertical Electrical Sounding (VES)
4. Drilling and Pumping test
5. Water Quality Analysis

I. Standard Operational Procedure for Aquifer Mapping and development of Management plans under NAQUIM

Introduction

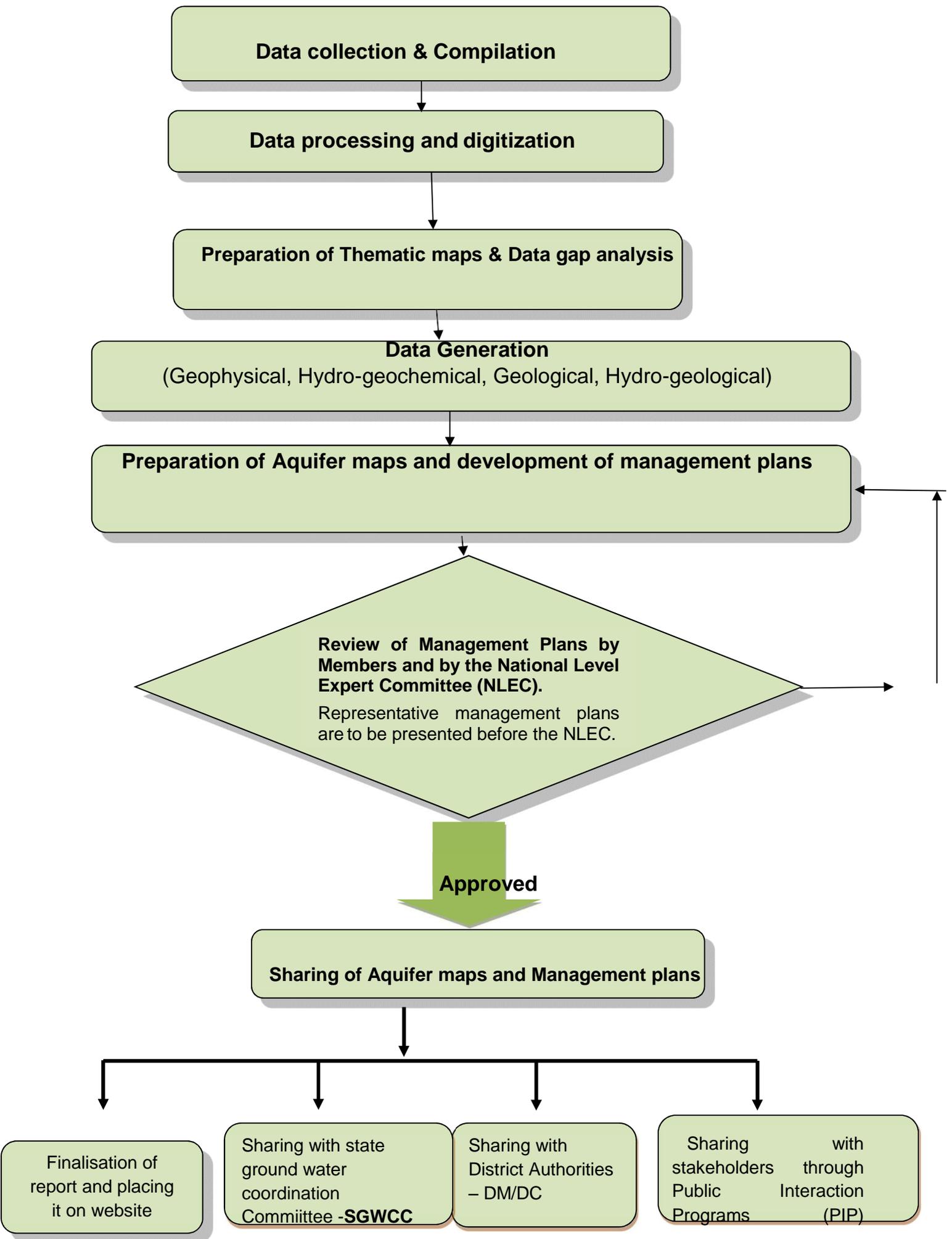
Aquifer Mapping is an attempt to combine a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability to have an accurate and comprehensive picture of groundwater in India. The aquifer mapping in different hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. Thus the crux of NAQUIM is not merely mapping but a pathway for effective and sustainable management of the groundwater resources of India.

The various steps involved in NAQUIM are

- I. Systematic data collection,
- II. Data compilation,
- III. Data processing and digitization
- IV. Data gap analysis,
- V. Data generation (Generation of data in the gaps),
- VI. Thematic layer preparation,
- VII. Aquifer mapping including 2D and 3D aquifer disposition,
- VIII. Preparation of aquifer management plans,
- IX. Review of management plans at three tier stages
 - a. Regional level; b. Member Level, c. National Level Expert committee (NLEC) level
- X. Sharing of outputs
 - a. SGWCC - state administration, b. DM/DC - district authorities, c. website-finalization of reports and placing on website and d. Through Outreach and Public Interaction Program for stakeholders at grassroot levels.

Timelines for various activities of Aquifer Mapping and management plan formulation

Activity	Timelines
Data collection, compilation	3 months
Thematic layer preparation and data gap analysis	1 month
Data generation	6 months
Preparation of aquifer maps and development of management plans	2 months
Review and finalization of the management plans (Regional Level, Member level, at National level through NLEC)	3 months
Sharing of outputs (Sharing with SGWCC, Sharing with DM/DC, Finalisation of reports and placing them on Website, Outreach Programmes)	9 months



Standard Operational Procedure for sharing of NAQUIM outputs with SGWCC

1. State Ground Water Co-ordination Committee (SGWCC) comprising a group of experts and representatives from the stake-holder departments in each state are to be formed.
2. The SGWCC must comprise of Principal Secretary of the nodal dept. for groundwater in the state as Chairman of the committee along with representatives of other stakeholder departments such as agriculture, rural development, PHED, forestry, horticulture, DST and other allied departments as Members of the committee. Technical experts of CGWB should be part of the SGWCC. Preferable Regional Director, CGWB should be the Member Secretary of the concerned SGWCC
3. Frequency of SGWCC meetings will be as per the requirement or as desired by the Chairman of SGWCC. However, reports for all the districts covered under NAQUIM studies are to be shared with SGWCC within three months of finalization of the management plan.
4. The presentation must include the following
 - i. Brief description of the NAQUIM area,
 - ii. Major groundwater issues,
 - iii. Aquifer disposition (GIS layers, lithologs, panel diagrams)
 - iv. Aquifer Management Plan which includes management strategies specific for the study area.
 - v. Any other relevant information, if necessary
5. There should be an interaction session after each presentation so that the Chairman and members of the committee can share their views/observations on the NAQUIM study undertaken.
6. Proper documents including photographs, minutes of the meetings are to be prepared and archived for follow up.

Standard Operational Procedure for sharing of NAQUIM outputs with District Authorities (DM/DC)

1. District wise NAQUIM findings are to be documented and submitted to the DM/DC through a covering letter. The covering letter to include probable schemes or programmes (like District irrigation plans, MGNREGS, Atal Bhujal Yojana, PMKSY-HKGP-GW, PMKSY-PCMD etc.) in which these findings/recommendations can be useful. Through the covering letter the DM/DC are to be request to consider the findings and recommendations of the report during formulation / implementation of various schemes and programmes at district level.
2. DM/DC is to be requested to forward the reports and findings with other line departments for possible integration. DM/DCs may also be requested to give copies of the letters to RD, CGWB for future consultations by CGWB with the concerned departments and their feedback.
3. DM/DC may also be assured of further technical assistance by the regional office of CGWB, if such assistance is sought by the concerned departments.
4. Date and time for power point presentation before the DM/DC are to be sought and wherever possible, presentations are to be made before the DM/DC and a copy of the report is to be presented.
5. Proper documents including photographs, minutes of the meetings (wherever relevant) are to be prepared and archived for follow up.
6. Feedback of the concerned departments is to be obtained on a yearly basis.

II. Standard Operational Procedure for Site Selection for Exploratory Drilling

Ground Water exploration is an important activity of Central Ground Water Board. Construction of exploratory wells provides an opportunity for direct access to the subsurface formations at a given site. Exploratory wells of different types like Main Well, Observation Well, Slim hole and Piezometers are constructed by CGWB for various purposes like knowing the subsurface strata, estimation of aquifer parameters, monitoring of water levels and water quality etc. Selection of a suitable site for exploratory drilling is the first step towards ground water exploration in a given area. For systematic hydrogeological studies and mapping an even distribution of the data is an essential pre-requisite. To ensure evenness in distribution of data points, a grid based approach is generally adopted. The various steps involved in selection of suitable site for exploratory drilling involves.

A. Activities to be carried out by the section dealing with Ground Water Exploration at the Region office level

- Define purpose: Purpose for construction of well and purpose specific tentative design is to be finalized.
- Tentative Area of Interest: Broad area of interest for the proposed construction is to be finalized.

B. Activities to be carried out by the Site Hydrogeologist

- Review of existing information: Existing data pertaining to the area of interest are to be plotted on a base map by Site Hydrogeologist
- Reconnaissance survey by Site Hydrogeologist for short listing the probable sites.

C. Activities to be done at the Regional Office and by the Site Selection Committee

- Constitution of site selection team by concerned Regional Directors of CGWB. The team member for site selection for in-house drilling would include Site Hydrogeologist and AEE/DIC. For drilling through outsourcing a representative from the concerned agency would also be a part of the site selection team.
- Joint field visit with site selection team for finalizing the site.
- Obtaining NOC for the selected site from the concerned authority (e.g Head of offices of the concerned School, Office/Government establishment in whose premises the site is selected or Sarpanch in case of Panchayat lands etc)
- The Proforma for site selection must contain the provision for full access to CGWB for carrying out sampling and other scientific studies even after handing over of the well to the Sate User agency.
- All the team members and local representative to sign on the site selection certificate (Annexure-I)

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Proforma for site Selection

Part –I

Topo sheet No. Co-ordinates
Village Block.....
Tehsil..... District

Location detail:

.....
.....
..... Approachability
.....
.....
.....

Representative of the Drilling Unit	Liaison Officer Representative of State/Local Govt. with official Seal	Site Hydrogeologist CGWB, _____
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Part-II

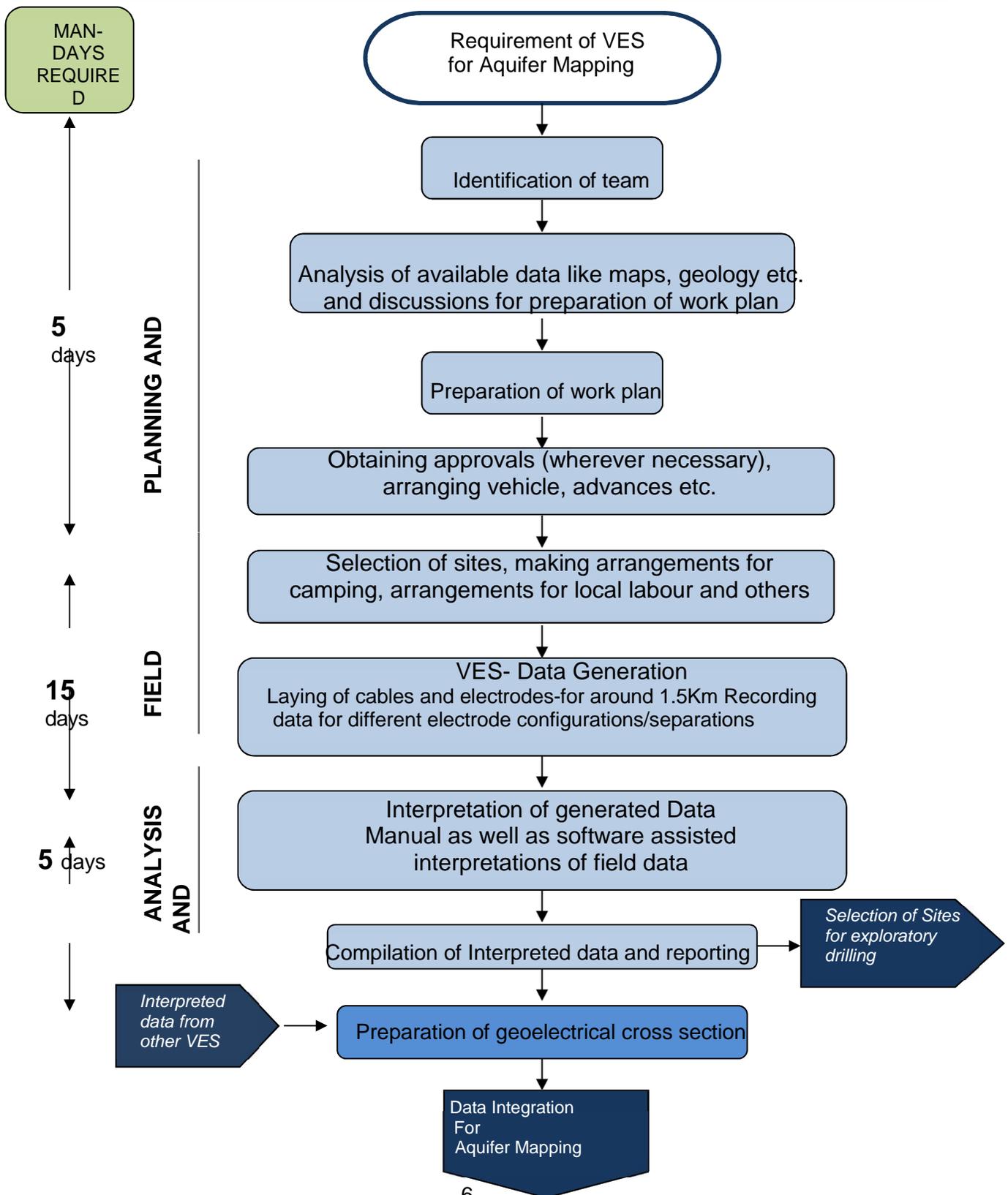
Sufficient scope exists for utilization of this well. In the event of its being successful in terms of performance fixed by Govt. of India, the successful tube well would be taken over immediately for effective utilization. It is understood that as per current policy of Government of India, tube well will be handed over to the user agency free of cost. It is also understood that full access will be allowed to CGWB even after Handing over of the well for carrying out sampling and other scientific studies whenever required. Any matter pertaining to the land will be responsibility of State Liaisoning Authority.

Liaison Officer
Representative of State/Local Govt.
(With official Seal)

III. Standard Operational Procedure for Geophysical Study: Vertical Electrical Sounding (VES)

PROCESS FLOW DIAGRAM

Geophysical Study: **Vertical Electrical Sounding (VES)** (Man-Days Required for conducting 20 VES: 25 days)



IV. Standard Operating Procedure for Geophysical Survey- Vertical Electrical Sounding (VES) for Aquifer Mapping

The following procedures may be adopting for conducting the VES by Electrical Resistivity Survey for AB/2 five hundred m in soft-rock and AB/2 three hundred m in hard rock formation and preparation of 3-D map of Aquifers delineated.

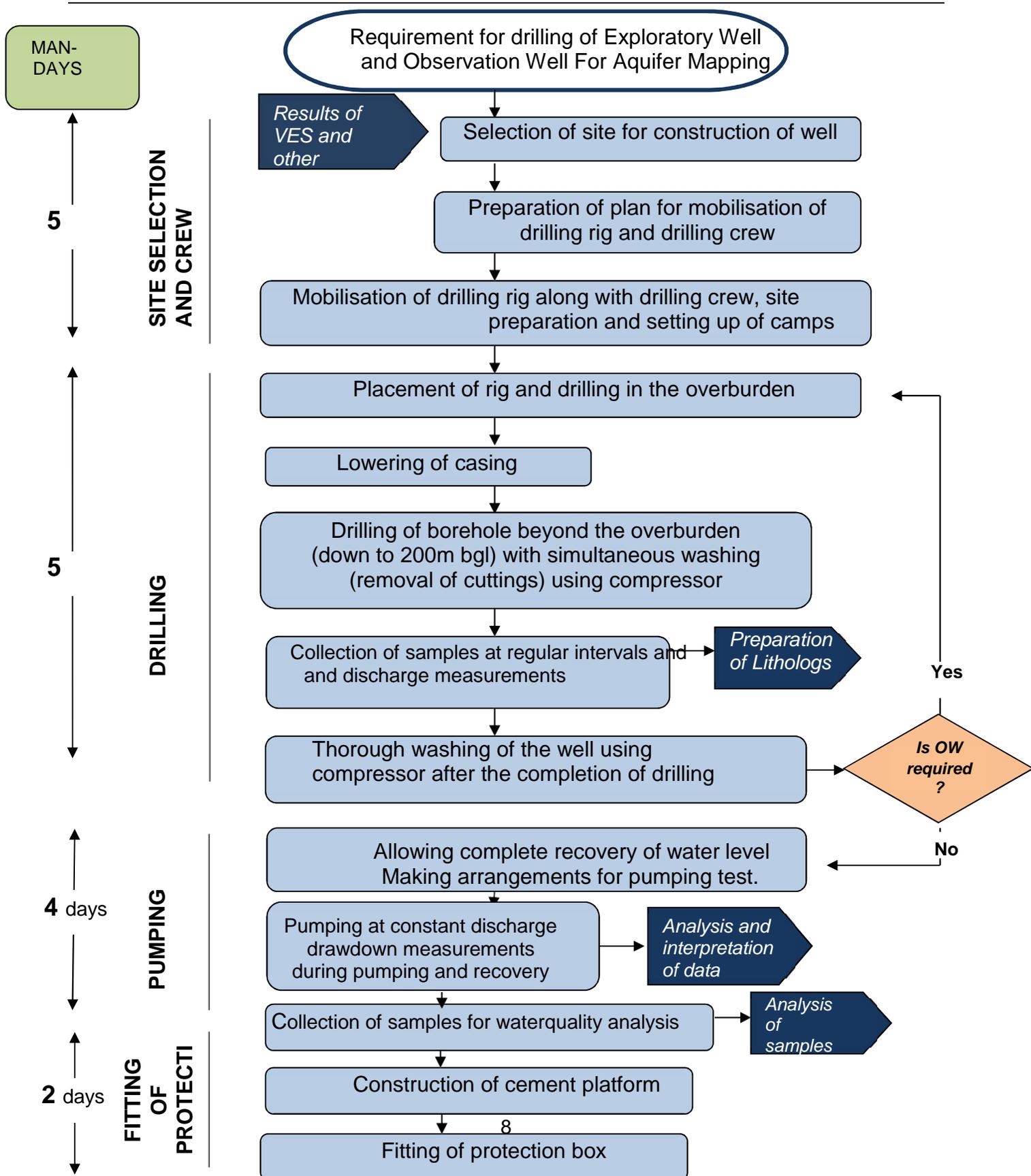
Description of work		Man-days Requirement	Remarks
A	Preparation for field like arrangement of Advances and vehicle	5	
B	Approaching the survey area for camping	1-2	400 – 700 Km
C	Visiting the survey area sites for planning the work	1	15 to 20 sites
D	Arrangement of local employment , contingent etc	1	
E	Data generation	1	Two VES
F	Interpretation of generated data	1	8 to 12 VES per GP and also depend on software etc.
G	Compilation of interpreted data	1	30 to 40 VES per GP
H	Preparation of Geo-electrical diagram	5	30 to 40 VES per GP

Manpower requirement for VES data generation			
Manpower		Number	
A	Team leader Geophysicist (Sr./Jr. Geophysicist)	1	
B	Geophysicist for field (Jr./Asst./STA geophysicist)	1	
C	Surveyor for alignment of electrodes arrangement	1	
D	Geophysicist for field (Jr./Asst./STA geophysicist)	1	If surveyor is not available.
E	Driver	1	
F	1. Contingent Labor (Semi skilled)	3	For Hard rock current electrodes separation 600 m
	2. Contingent Labor (Un-skilled)	3 to 5	
G	1. Contingent Labor (Semi skilled)	4	For soft rock current electrodes separation 1000 m.
	2. Contingent Labor (Un-skilled)	4 to 6	

Interpretation , preparation of diagram and reports: All two to three Geophysicists together

V. Standard Operational Procedure for Drilling and Pumping test

PROCESS FLOW DIAGRAM Drilling and pumping test in Hardrock Areas (Man-Days required: 16 days)



VI. STANDARD OPERATING PROCEDURE FOR EXPLORATORY DRILLING

(TENDERING PROCESS)

S.No	Activity	Man-days Required
1	Receipt of Indent /proposal for exploratory drilling	-
2	Preliminary examination of proposal and firming up the quantities, well design etc	7 working days from the date of receipt of indent/proposal
3	Preparation of BOQs and estimate of proposed work	5-10 working days depending upon the volume of proposed work
4	Seeking administrative approval of proposed work	7 working days if falls in the power of Chairman CGWB "or" 30 working days if beyond the power of Chairman CGWB
5	Publishing of tender document	3 working days from the date of receipt of AA
6	Pre-bid meeting	12-15 days from the date of publishing
7	Opening of received tender	30-45 days from date of publishing depending upon the volume of work
8	Evaluation of the received tenders	15 working days from the date of opening
9	Obtaining expenditure sanction	7 working days from the date of receipt of evaluation report if falls in the power of Chairman CGWB "or" 30 working days if beyond the power of Chairman CGWB
10	Award of work to the successful bidder(s)	3-5 working days after the receipt of expenditure sanction
11	Receipt of performance security	15 days from the date of award of work
12	Monitoring of ongoing work	Daily basis by concerned Regional Directorate
13	Submission of fortnightly reports to the authorities	Fortnightly report to be submitted by Regional offices in prescribed format.
14	Release of payments to the contractor	As per payment condition in tender document, however monthly payments can be made.
16	Finalization of contract	Deductions, payments as per terms and conditions and closing of contract.

VII. STANDARD OPERATING PROCEDURE FOR CONSTRUCTION OF EXPLORATORY WELL IN SOFT- ROCK (ROTARY METHOD)

S.No	Descriptions of Activities	Time Frame
1	Site preparation & Placement of Rig	2 days
2	Pilot hole drilling(300m)& Sample collection	3 days
3	Electrical Logging & Assembly decision	1 day
4	Reaming operation , collection of stores &Assembly preparation	4 days
5	Bore hole washing/thinning of Mud with Mud Pump &Lowering of Assembly	2 days
6	Gravel packing	1 day
7	Cement sealing & further filling of the hole above the Cement seal with clay/drill cuttings	2 days
8	Development by compressor	1 day
9	Pumping Test	2 days
10	Construction of Cement Platform	1 day
11	Fitting of Protection box	1 day

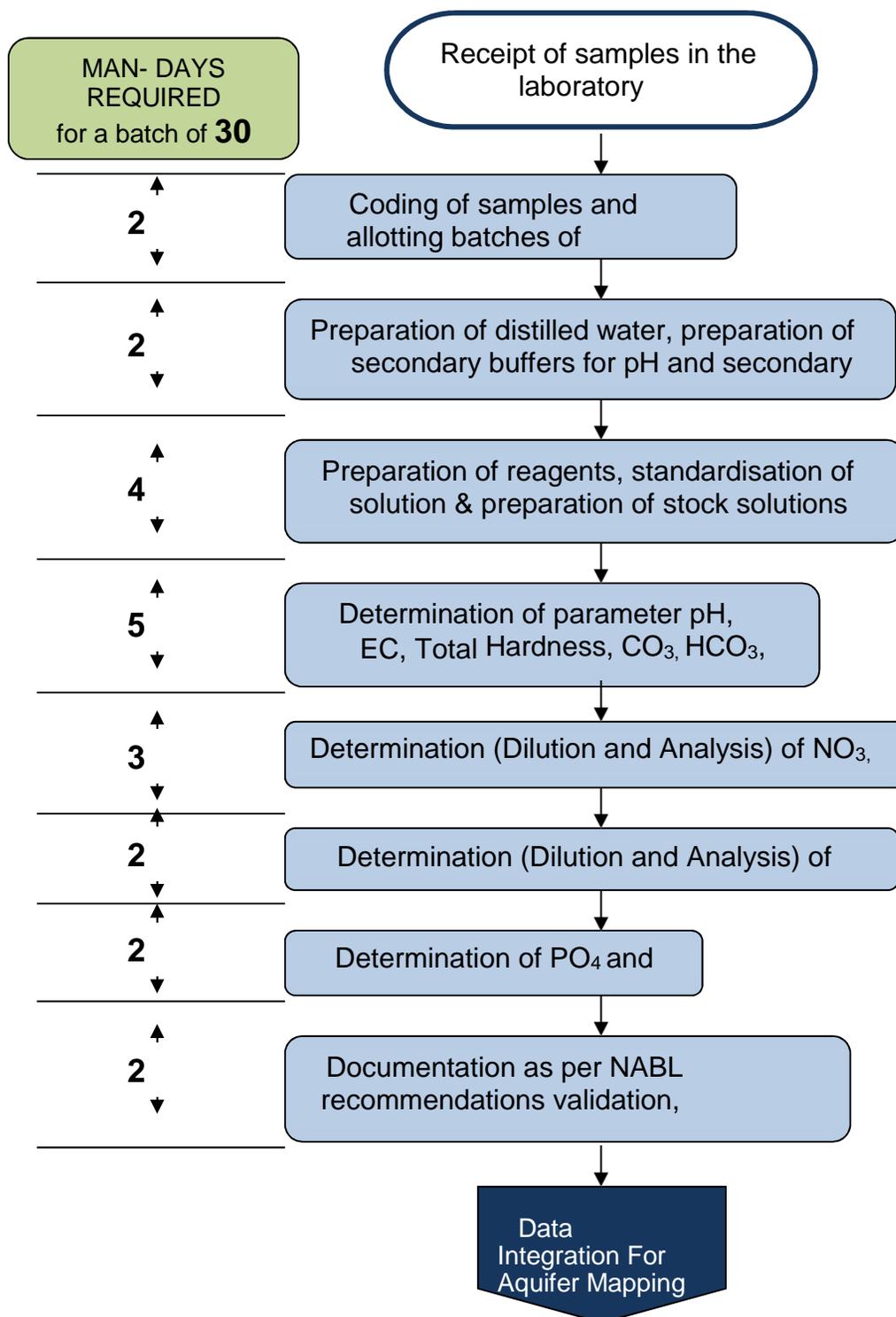
NOTE: The above time frame is subject to the ideal formation, no waiting for break downs & stores and instant Hydrogeological decisions on the spot.

VIII. Standard Operational Procedure for Water Quality Analysis

PROCESS FLOW DIAGRAM

Analysis of Water Samples for basic quality parameters
(pH, EC, CO₃, HCO₃, Cl, Ca, Mg, Hardness, NO₃, SO₄, Na, K, F, PO₄ and SiO₂)

(Man-Days Required for analysis of 15 parameters for a batch of 30 samples: 22 days)



IX. STANDARD OPERATING PROCEDURE (SOP) FOR ANALYSIS OF WATER SAMPLES FOR BASIC WATER QUALITY PARAMETERS

(pH, EC, CO₃, HCO₃, Cl, Ca, Mg, Hardness, NO₃, SO₄, Na, K, F, PO₄ and SiO₂)

1. Receiving samples Mostly by In-charge of the Chemical Lab

- a) Checking all the details given by the Field Officers as per the NABL norms
- b) Checking of all the samples for Physical condition.
- c) Instructions to be given for the next step if any.

2. Coding of samples based on type of Analysis

- a) Checking for the details given by the field officer matching to List and Samples
- b) Checking for Leakages of samples.
- c) Coding of samples on the samples as per the norms.
- d) Recording in the Registers as per the norms.
- e) Some of the samples to be retrieved from the analysed samples for numbering for Re- checking of the analysis suggested by Technical Manager(NABL)

3. Allotting samples to Chemists

- a) Checking the need of type of Analysis on the basis of Request of Field officer
- b) Identifying the chemist capability for the particular analysis on basis of norms
- c) Allotting to chemists basing on his work load
- d) Allotting to Chemists re-checking samples as per the NABL norms

4. Planning and Analysis of samples by Individual Chemists

- a) Planning for the analysis on the basis of remaining Lab staff availability, like Lab assistants/attendants and Lab space
- b) Preparation of distilled water / ultra-pure water (EC < 1.0µS/cm) and checking for their quality for pH, EC/TDS, Silica and Iron
- c) Glassware cleaning and drying supervision for particular analysis
- d) Preparation of secondary Buffers standards for pH meter
- e) Preparation of Secondary standards for Conductivity, minimum of two standards, it may vary depending on type of samples.
- f) Checking for Cell constant of Conductivity meter
- g) Preparation of Standards for each Parameter, like Carbonate standard, Chloride standard, Sulphate standard, Nitrate standard, Fluoride standard, Calcium Standard, Sodium standard, Potassium standard, Phosphate standard, Silica standard, etc for each time.
- h) Preparation of Diluted standards from the above for the daily use and checking their concentrations for correctness.
- i) Preparation of various Buffer solutions.
- j) Preparation of Indicator solutions/salts and Checking for their correctness
- k) Preparation of standard Acid solution for Alkalinity, Silver Nitrate for Chloride, EDTA for Hardness, Calcium and Magnesium.
- l) Calibration of above solutions with NIST traceable standards. Each solution has to be titrated for 3 times minimum.
- m) Checking the Correctness of the solution for their concentration.
- n) Samples to be kept ready for the analysis for the day.

- o) Pipetting of samples for each parameter (for Carbonate, Bicarbonate, Chloride, Hardness and Calcium) of three times.
- p) Titration of the above for at least two repeated values of titration.
- q) Preparation Sodium and Potassium diluted standards
- r) Samples dilutions for Sodium and Potassium basing on the Instrument capability
- s) Standardising the flame photometer for each parameter
- t) Analysis of samples for Sodium and Potassium on Flame Photometer
- u) Checking the analysis with NIST standards for Sodium and Potassium
- v) Checking for the Turbidity meter for its condition and calibration as per the NABL requirement with NIST standard.
- w) Preparation of Sulphate standards for day use.
- x) Preparation of Sulphate buffer
- y) Preparation diluted samples for analysis
- z) Addition of buffer and Barium chloride reagent
- aa) Stirring sample and standards in uniform manner and time
- bb) Preparation of standard graph for Sulphate
- cc) Taking Nephlo turbidity meter or spectrophotometer readings of sample
- dd) Comparing the results with standard graph and recording values of samples
- ee) Checking for the Spectrophotometer correctness, as per the guidelines given by -NABL
- ff) Preparation of the diluted standards(minimum of 5 standards) for Nitrate
- gg) Measurement of Spectrophotometric readings at 2 different wavelengths.
- hh) Preparation of Standard graph
- ii) Preparation of samples for Nitrate analysis with required reagents like HCl addition.
- jj) Dilution of Samples into the instruments measuring range.
- kk) Taking UV-Vis Spectrophotometric measurement of samples
- ll) Comparing results with standards graph and recording values of samples
- mm) Preparation of Phosphate standards diluted for day use
- nn) Preparation of different reagents (3-5 reagents and colour developing dye)required for Phosphate analysis
- oo) Preparation of Diluted Phosphate standards
- pp) Dilution of samples into the range of measurement
- qq) Addition of reagents for colour development and wait for the time specified in the method.
- rr) Recording the measurements on spectrophotometer
- ss) Preparation of Graph for standards
- tt) Comparing values of samples with graph and recording results
- uu) Preparation of diluted standards for Fluoride by Ion-meter (If it is with spectrophotometer, it will take more time and more dilutions.)
- vv) Preparation of Buffer for Fluoride
- ww) Preparation of Fluoride electrode for analysis
- xx) Addition of buffer / mixed reagents to standards and samples
- yy) Measurement of standards and samples while stirring the samples, if the values are exceeding then to be diluted
- zz) Recording the results of the above measurements.
- aaa) Preparation of Silica standards diluted for day use
- bbb) Preparation of different reagents (3-5 reagents and colour developing dye) required for Silica analysis
- ccc) Preparation of Diluted Silica standards
- ddd) Dilution of samples into the range of measurement
- eee) Addition of reagents for colour development and wait for the time specified in the method.
- fff) Recording the measurements on spectrophotometer
- ggg) Preparation of Graph for standards

hhh) Comparing values of samples with graph and recording results

5. Compilation of results

- a) All the results recorded should be compiled in the record book
- b) Appropriate dilution factors to be included while compiling the results

Based on the above steps / work load, the following man-days requirement is applicable to Chemist, who has not been assigned any other duty beside analytical work and also depends upon the logistic support, infrastructure and Chemicals & Glassware required.

Man-days requirements For analysis of 15 basic water quality parameters for a batch of

Sl. No.	Activity	Man-days Required
1	For Step 1, 2 & 3 above	2
2	For Step 4a to 4 e above	2
3	Preparation of reagents, standardisation of solution & preparation of stock solutions for 15 parameters	4
4	Determination of pH, EC, CO ₃ , HCO ₃ , Cl, Ca & Mg	5
5	Determination of NO ₃ , SO ₄ (dilution & analysis)	3
6	Determination of Na & K (dilution & analysis)	2
7	Determination of PO ₄ & Silica	2
8	Documentation as per NABL ,Validation of data, preparation , computerisation & reporting of results	2
	Total	22