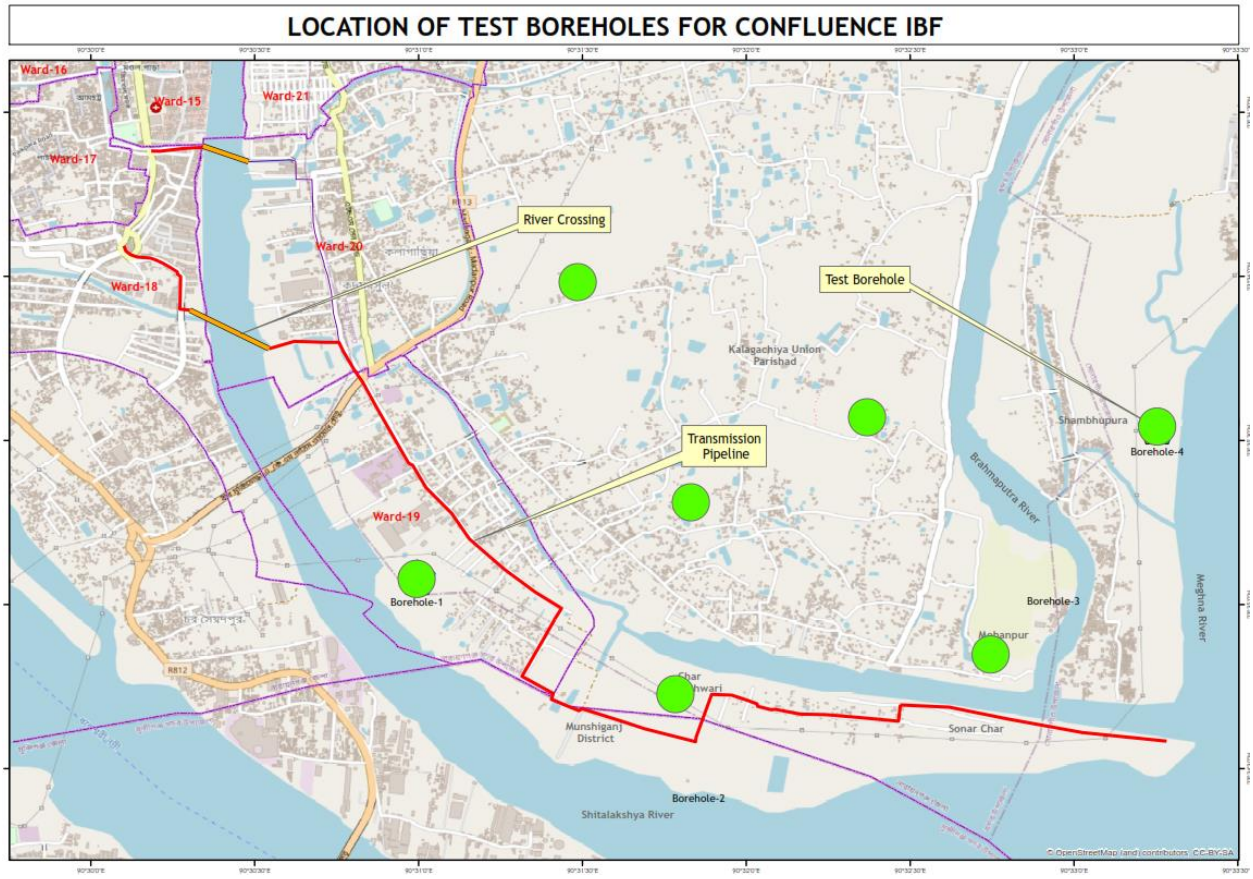
Terms of Reference

May 2023

1 PROJECT LOCATION

The new wellfield will be located in the south Shambupura area and will draw on water at the confluence of Dhaleswari, Shitalakshya and Brahmaputra rivers as shown in the following sketch.



2 SCOPE OF WORKS

The project shall comprise the following tasks:

2.1 Task 1 – Assess Groundwater Potential and Identify Geophysical Strategy

- assess the groundwater potential of the project area by identifying the target aquifer(s), their types (porous, fractured or karstic) and spatial distribution.
- assess the groundwater potential by establishing a water balance for the area to present a conceptual hydrogeological model of the investigation area.
- assess geormophological features relevant to groundwater dynamic process (e.g., drainage patterns, vegetation cover variations).

Based on the conceptual model, an appropriate geophysical investigation strategy shall be designed that is coherent with:

- the identified target aquifer type (porous, fractured or karstic),
- the expected depth of the target aquifer and the baseline elevation (estimated depth to groundwater which determines the minimum required investigation depths).

Unless a perfectly horizontally layered subsurface conditions can be assumed, a line profile should be defined within the geophysical strategy, to identify possible anomalies before running any Vertical Electric Sounding (VES).

The outcomes of the geophysical investigation strategy shall be presented with the Hydrogeological report and will confirm the specific geo-electrical investigation methods to be employed. Acceptable methods include:

- VES (vertical electrical soundings): to be applied in horizontally layered aquifers. These can either be porous aquifers or, in many cases, the weathered carapace of the basement. At each measuring point, 2 perpendicular vertical electrical soundings to be carried out to guarantee the validity of the assumption of horizontal layering.
- Geo-electrical profiling: vertical, steep aquifers (fault zones, fractures)
- ERT (electrical resistivity sounding): can be used for horizontal and vertical/steep structures.

2.2 Task 2 – Geophysical Investigation and Supervision of Drilling

The following activities shall be completed:

a. Carry out the geophysical investigation according to the investigation strategy and interpret results.
b. Presenting the results of the geophysical investigation, including the raw data sets, the qualitative interpretation of the type curves in terms of layer sequence (for VES investigations) and inversions results, and the identification of the drilling locations and precise description of drilling strategy and design.
c. a well-design shall be established. The design shall maximize water inflow and minimize well-head-losses.
d. The proposed drilling sites shall be marked with a concrete marker with GPS.

2.3 Task 3 – Arrangement and Supervision of Drilling

a) The firm shall supervise and document on a daily basis the drilling, development and test pumping of the proposed boreholes and hand-in a daily drilling progress report.
b) After the first borehole completion, the general well-design described in the Geophysical Report may have to be adapted according to site conditions and would need final approval before the drilling process can continue. This updated general design must in no way interrupt the well-construction process and therefore needs to be done on the spot so that approval can be given within 24 hours.
c) water sampling, geological logging and water quality analysis (chemical and bacteriological). Ensure and retrieve proof that bacteriological analyses were carried out within 24 hours after sampling.
d) Adapt the general well-design according to the specific conditions at each well location, basing it on the geological log and on the results obtained from the pumping test.
e) Supervise installation of screens, casings, gravel pack, impermeable seals, well-heads etc. Ensuring quality control measures upon well-completion, e.g., borehole camera inspection.
f) For each specific borehole, prepare a detailed borehole completion report.

3 APPROACH, METHODOLOGY AND REQUIRED OUTPUTS

3.1 Task 1 - Hydrogeological Survey

a) **Desk review and data-acquisition**: review of existing data, geological hydrogeological, topographical maps, satellite images, previous existing hydrogeological/geological studies and borehole site investigations in the area, borehole and surface water records, ground water quality data etc.

b) **Hydrogeological fieldwork**: detailed reconnaissance survey of project area. (GPS coordinates, water level measurements, TDS and EC, condition, usage and performance where applicable) inspection of geological, geomorphological and structural characteristics of the investigated area; verification of existing data and findings.

c) Analyse all the above data to:

(i) **Identify target aquifer(s),** clearly stating their geometrical characteristics: horizontal (layered) or vertical (faults and fractures)? (this determines the choice of the geophysical investigation method. Horizontal aquifers = vertical electrical soundings with two perpendicular layouts at each position to assure horizontality. Vertical (steep) aquifers = e.g., localisation by geo-electrical profiling, or electromagnetic methods (e.g., VLF-EM) and combination with subsequent vertical sounding. ERT (electrical resistivity sounding appropriate in both geometrical configurations)

(ii) **Identify and describe groundwater recharge and discharge areas and processes** (diffuse versus concentrated recharge) and estimate the groundwater baseline elevation (elevation below which the subsurface is assumed to be saturated): elevation of nearby spring, elevation of lake, flowing river or projected groundwater elevation from nearby wells.

Hydrogeological report including:

a) A conceptual hydrogeological model of the study area, clearly identifying the target aquifer types (porous, fractured or karstic), their geometrical characteristics (horizontal or vertical-steep aquifer), the recharge processes and assumed groundwater flow direction as well as a water balance of the area.

b) A figure illustrating the conceptual model and indicating preferential areas for groundwater prospection

c) Data base including the compiled geological and hydrogeological data in electronic form (Excel, MSAccess, etc)

d) Based on the conceptual hydrogeological model detailed description of the investigation strategy and its rational:

a. Justification of chosen method and investigation depth (recalling target aquifer and groundwater baseline elevation) and description of calibration method (e.g., with borehole logs), description of expected geophysical response of the target aquifer (e.g., electrical resistivity range).

b. Localization of the geophysical measuring points on a map and on the figure of the conceptual model.

3.2 Task 2 - Borehole Siting & Geophysical Survey

The firm will plan and execute the geophysical exploration phase according to the investigation strategy. The geophysical survey includes retrieval of data, interpretation of all geophysical data as well as reporting and selection of the most suitable sites for drilling.

Specific investigation method requirements:

a) **Vertical electrical soundings (VES):** for any vertical electrical soundings that are carried out, the qualitative type-curve analysis identifying the number of layers and the respective resistivity contrasts has to be included in the interpretation and the reporting and has to be used to constrain the computed inversion.

For vertical electrical soundings, two perpendicular measurement directions have to be carried out to assure that the inversion assumption of horizontally layered subsurface conditions is valid.

During the execution of the survey programme, the geophysical investigations will include compilation and interpretation of all the collected geophysical data.

Geophysical Survey Report Include:

The geophysical campaign shall clearly explain rationale of choosing each measurement site a table with the exact measurement locations (GPS coordinates) and also indicating the measurement directions shall be provided.

Results and interpretations of each measurement site shall be described separately.

A well-design shall be established to maximise water inflow and minimise well-head-losses: how this optimisation is addressed shall be clearly stated in the report.

In the field, the selected sites shall be marked with a concrete marker and shown on a picture plate (Google Earth) and indicated on a sketch map included Geophysical Survey Report.

3.3 Task 3 - Supervision of Drilling Activities

The firm shall supervise all the drilling process at all times on site and carry out a separate geological and hydrogeological borehole logging, which is updated each day.

Documentation and monitoring of the well-development process: measuring the evolution of the yield versus time (since well-development started) and the temporal evolution of the turbidity.

Monitoring and following the pumping test according to standard formats: step-draw-down test to be carried out with at least 4 steps present in the daily progress report the characteristic curve and the safe yield.

After the first borehole has been completed, the general well-design described in the Geophysical Report may have to be adapted according to site conditions and would need final approval before drilling can continue. This updated general design must in no way interrupt the well-construction process and therefore should be done on the spot so that approval can be given within 24 hours.

The firm shall ensure that the drilling contractor carries out water sampling, geological logging and water quality analysis (chemical and bacteriological). The firm shall also ensure and retrieve proof that bacteriological analyses were carried out within 24 hours after sampling: carry out parallel measurements of water quality (electrical conductivity and turbidity).

The general well-design shall be adapted according to the specific conditions at each well location, based on the geological log and on the results obtained from the pumping test.

The selected firm shall supervise the installation of screens, casings, gravel pack, impermeable seals, well-heads etc. Ensure that the recommended drilling depths, design and materials are followed and propose and carry out quality control measures upon well-completion (e.g., borehole camera inspection).

For each specific borehole, a detailed borehole completion report with all necessary recommendations (e.g., pump capacity, optimum depth of installation, periodic water quality analysis) shall be prepared in accordance with the standard format.

Reporting Requirements: Drilling Supervision Reports

a) Daily drilling progress report with attached borehole log and a short summary of daily activities and special observations and difficulties encountered. If any difficulties that are slowing down the process have been encountered, then the daily activity report needs to suggest remedial measures and needs to be approved.

b) After the first borehole completion, the general well-design described in Phase-2 Geophysical Report has to be re-evaluated and either adapted or confirmed: if the well-design needs to be adapted, then an amendment to the Phase 2 geophysical report for the well-design has to be delivered and requires approval (within 24 hours) before drilling can proceed.

c) All the documents established during the drilling phase by the firm shall be summarized in a Phase 3- Drilling Report, which will also include a quality control review of the drilling report from the drilling contractor

d) Compile the reports into a comprehensive final report (2 hard copies plus softcopies including all the raw data): this report needs to be approved prior to final payment. This report includes a chapter on the efficiency of the hydrogeological-geophysical investigations with respect to the actual findings during the drilling campaign.