Brief Summary of the Hydrogeology of Bangladesh

by

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Introduction

The average annual precipitation in Bangladesh ranges from about 50 inches in the west-central part to about 200 inches in the northeast. Most of the rain falls during the southwest monsoon so that local precipitation is heavy at the same time flood waters of the Brahmaputra and Ganges rivers arrive. The result is that most years about 50 percent of Bangladesh is inundated; in very wet years inundation may exceed 70 percent of the total land area. Consequently, over much of the country the annual recharge to the ground-water reservoir is large. Annual fluctuations of the ground-water level are commonly about 10 feet in the northern part of the country. If a storage coefficient of 0.2 is assumed, annual recharge may be about 24 inches of water. Although the amount of recharge is different from area to area, it is almost everywhere very substantial in the Ganges-Brahmaputra Delta.

Bangladesh is underlain near the land surface almost exclusively by poorly consolidated or unconsolidated rocks of Tertiary and Quaternary age. A buried basement complex of Precambrian crystalline and Gondwana sedimentary rocks slopes southerly from rather shallow depth along the northern border with Assam to perhaps 2,000 feet beneath Dacca and even greater depths to the south. Marine sedimentary rocks of Tertiary age overlie the basement complex. Small patches of sedimentary rocks, some of Cenozoic age, are exposed along the Assam border and constitute the folded rocks of the Chittagong Hills and their northern extension into the Sylhet District. Much of the folded rock sequence is of Pleistocene age.

Alluvial deposits of probable Quaternary age, unconsolidated except for locally cemented kankar, overlie the marine sedimentary rocks. The alluvial deposits range from a feather edge bordering the marine sedimentary rocks of the northeast and east to at least 2,000 feet thick near Dacca. In the northwestern part of Bangladesh, the Thakurgaon area, the alluvium is at least 400 feet thick; near Bogra it is almost 500 feet thick. The alluvium (including deltaic deposits) covers nearly all of the country except for the Chittagong Hill tracts and much of the Sylhet area.

The alluvium was deposited chiefly by the present and ancestral Brahmaputra, Ganges, and Meghna River systems. It is likely that their courses have shifted greatly, especially during the Pleistocene. For example, the Ganges and perhaps also Brahmaputra may have even drained northwestward into the Indus River at times. Shifts in the drainage system have also been recorded during historic times. Sea levels during times of maximum Pleistocene glaciation were probably as much as 500 feet below the present level and during some interglacial periods perhaps 100 feet above present level. Scour and deposition because of changes in base level and because of large stream discharges and sediment loads during parts of the Pleistocene as well as normal channel shifting gave rise to a complex of deltaic alluvium. Areas of older Pleistocene alluvium north of Dacca and west of Bogra rise above younger Holocene alluvium. The combination of large recharge and thick alluvial deposits indicates that Bangladesh is favorable for large-scale development of ground water.

Major Hydrologic Areas

Figure 1 shows the major subdivisions of Bangladesh in terms of ground-water conditions.

Younger Alluvium: The area shown as "I" offers the best possibility for the development of large-capacity wells. Unconsolidated materials, including appreciable thickness of sand, extend to depth of at least several hundred feet.

The northwestern part of area I is the most favorable part of the country for ground-water development. Alluvial deposits are relatively coarse, constituting in large part the subaerial fan of the Tista River. Permeable surface soils permit a high rate of percolation of rain. Depths to water are shallow, permeability of the aquifers is high, and ground water is generally unconfined. Most domestic wells are less than 25 feet deep. Existing wells and pump tests indicate that yields of 1 to 4 cusecs (cubic feet per second) can be obtained at most places. Generally, the existing irrigation tubewells are drilled to depths of about 300 feet. Most wells 100 to 150 feet deep would yield 1 to 2 cusecs. Transmissivities are about 100,000 gpd/ft (gallons per day per foot) so that tubewells have an average specific capacity of about 50 US gallons per minute per foot of Drawdown. Surface tanks are relatively uncommon because the bottoms are too

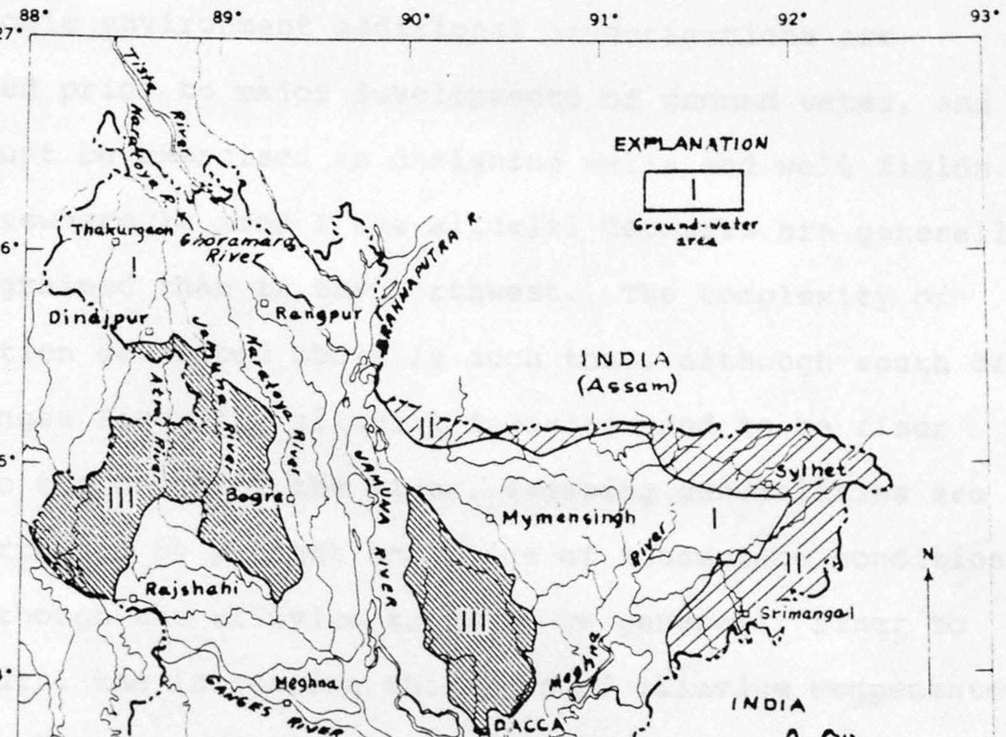

Figure 1--Map of Bangladesh Showing Approximate Boundaries of Ground-Water Areas

SCALE 1:4 000 000

25 0 200 KILOMETERS

25 0 200 MILES

permeable to retain water. Despite the favorable geo-hydrologic environment additional investigations are required prior to major developments of ground water, and care must be exercised in designing wells and well fields.

Elsewhere in area I the alluvial deposits are generally finer grained than in the northwest. The complexity of deposition described above is such that, although south of the Ganges River the alluvial deposits tend to be finer than to the north of the river, sweeping generalities are not warranted by present knowledge of subsurface conditions.

Although the alluvium tends to be generally finer to the south, the increasing thickness of alluvium compensates for the lower permeability. Consequently, transmissivities appear to be about 100,000 gpd/ft over much of the area. Specific capacities at most places are 20 to 40 gallons per foot. Irrigation wells yielding 1 to 2 cusecs would generally need to be 200 to 400 feet deep. At many places in area I larger yields could be obtained by drilling wells deeper (increasing screen length) and (or) installing larger pumps. Water is at many places semi-confined by clay layers. The ground water is of good quality for irrigation and domestic use, although the iron content is locally high.

<u>Areas of Complex Geology</u>: Poorly consolidated and commonly folded rocks of Quaternary and Tertiary age are exposed or

probably lie close to the surface in much of area II. Piedmont deposits occur along the northern border of the area. Area II may be characterised as one in which careful local checking is required prior to planning large-scale withdrawals of ground water. In the vicinity of Comilla, for example, at many places it is possible to drill wells of moderate depth yielding more than 1 cusec. At some places, however, near Comilla yields are very low. In the vicinity of Srimangal some test holes several hundred feet deep have yielded very little water. At scattered points, especially in the piedmont deposits, confined water has been encountered and a few wells flow naturally.

Older Alluvium: Very little attempt has been made to develop large-discharge wells in area III. Surficial deposits of the area consist of older alluvium, chiefly the Pleistocene formation known as Madhupur Clay. The assumption that clay extends to great depths has discouraged exploration for water. Clay has been recorded to a depth of as much as 400 feet. At Dacca, however, the good yields of wells which tap sands beneath the Madhupur Clay and indications from geophysical probes west of Bogra suggest that parts of area III should not be ruled out of consideration. Considerable test drilling and geologic mapping would be required to determine the extent, lithologic character, and thickness of clay and sand strata. Aquifer tests by pumping would be necessary to predict both immediate and long-term yields of aquifers. At present (1972) there is no reliable information available as to whether there are wide-spread water-bearing sand beds within or below the Madhupur Clay.

Coastal Area: Area IV of deltaic and beach deposits has been but slightly explored. The little work that has been done indicates that ground-water conditions are far from uniform. Aquifers are generally fine-grained and of low yield. In some areas saline water has been found at depth. In many areas influenced by tidal salt water, shallow alluvial deposits yield water that is highly mineralized and unsuitable for municipal or irrigation purposes. Locally, some shallow wells yield water of poor quality that is of necessity used for domestic supply.

In much of area IV, including most of the offshore islands, fresh water has been encountered at considerable depth below land surface and beneath brackish or salt water. In such places depths to fresh water commonly exceed 900 feet. One 1,700-foot well at Mangla Port obtained no fresh water, although a well at the shore of the Bay of Bengal to the south obtained fresh water at 1,500 feet. Deep and costly test drilling would be required to map out the depth and lateral extent of the fresh water aquifers.

Salinity of water and low permeability make it unlikely that wells of large yield can be drilled for irrigation, municipal, or industrial use in area IV. Control of migration of salt water in response to pumping would be required.

State of the Art

Implementation of several ground-water investigatory and development programs in Bangladesh was halted or aborted by events in 1971. Several prefeasibility studies for ground-water development and some spot studies have been made. A Ground Water Circle established in the Water and Power Development Authority has collected and compiled many of the data available for Bangladesh. The Agricultural Development Corporation and the Directorate of Public Health Engineering have drilled hundreds of wells, chiefly through contractors.

A small cadre of partly trained, although very inexperienced, energetic geologists and engineers exists in the Ground Water Circle. A few individuals in the Directorate of Public Health Engineering and Agricultural Development Corporation have experience and ability as engineers, geologists or chemists in ground-water work, but are not experienced in areal investigations.

Problems

All the current (1972) economic and administrative problems of Bangladesh apply as well to ground-water investigation and development. Transport and power nets, which were not adequate in 1970, have been severely damaged. Also access to field sites, especially for well-drilling equipment, is very difficult in much of the country. Only few personnel with competence in the disciplines related to ground water are available for the requirements of a nation of some 75 million people. Real or potential problems of large ground-water development, in addition to access, equipment, power and personnel, are geohydrologic in nature. The following questions require consideration.

(1) Is recharge sufficient to support long-term, massive pumping of ground water?

(2) Will large pumpage lower water levels sufficiently to deplete stream flow and interfere with low-lift pumping schemes? (This is likely at places.)

(3) Will well interference raise pumping costs excessively?

(4) Are corrosion and encrustation of well casings and screens serious problems?

If so, can wells be constructed in such a manner as to control corrosion and encrustation?

(5) Can wells of sufficient yield for irrigation be obtained in the hilly areas?

(6) Can wells be designed so as to be efficient but not too costly? (All large-scale well schemes under consideration in 1970 were preplanning well performance without due regard for geology and hydraulics.)

(7) Will pumping from deep aquifers in the coastal area induce migration of salt water to wells? Can proper management control encroachment?

(8) Will pumping induce land subsidence?