PN-AAT-439 41395

WM-19-85

BANGLADESH AGRICULTURAL RESEARCH PROJECT PHASE-II

GROUNDWATER INVESTIGATIONS
Report on a Training Course

Calvin G. Clyde

BANGLADESH AGRICULTURAL RESEARCH COUNCIL
INTERNATIONAL AGRICULTURAL DEVELOPMENT SERVICE
April 1985

PN-AAT-439
41395

Course on

GROUNDWATER INVESTIGATIONS

Presented by

BANGLADESH AGRICULTURAL RESEARCH COUNCIL

Held at

BANGLADESH RICE RESEARCH INSTITUTE
Joydebpur, Gazipur

From

1 April to 28 April 1985

In Collaboration with the

INTERNATIONAL IRRIGATION CENTER
UTAH STATE UNIVERSITY
LOGAN, UTAH

In accordance with an Agreement Between

the INTERNATIONAL AGRICULTURAL DEVELOPMENT SERVICE

and

UTAH STATE UNIVERSITY

Prepared by
Dr. Calvin G. Clyde, Course Director
April, 1985

A C K N O W L E D G E M E N T

During a planning visit to Bangladesh during the period 14-21 February 1985, the officials most helpful in the Bangladesh Agricultural Research Council (BARC) in arranging for the course included Dr. E. Ahsan, Chairman (Acting) at BARC and Dr. K. A. Haq, Member-Director of Agricultural Engineering. In addition Dr. Haq as Head Agricultural Engineering at the Bangladesh Rice Research Institute (BRRI) was very helpful in day to day coordination and smooth operation of the course.

Under the direction of Dr. David Daugherty, IADS Project Supervisor, the IADS support unit gave indispensible help in duplicating course material when the textbooks were late being released, in providing transportation and travel assistance and in making arrangements for general activities such as field trips. Those especially helpful were Dr. Carlos Garces, Agricultural Engineering, Dr. Roger Lazaro, IWM Specialist and Mr. N. A. Akhand, PSO, BARC.

At BRRI the shop helped with the field work by making and installing flow measurement equipment. Mr. A. Sattar, SSD, BRRI, who was also a course participant, provided much help in the field work through his knowledge of the well locations and groundwater conditions at BRRI. Mr. Billah, Training Specialist, BRRI provided local assistance with course facilities.

The efforts of the hostel staff to make the accomodations as pleasant as possible is appreciated.

Finally the instructors are indebted to the participants, without whose enthusiasm and dedication the course would not have succeeded. May their calculators always give the right answers!

Calvin G. Clyde
Course Director

INTRODUCTION

During the negotiation of the agreement between BARC and Utah State University the course objectives were outlined. It was agreed that the course should accomplish the following:

Be technically well founded in theory and practice of ground water investigations,

Have a strong component of practical problem solving,

Enhance the professional competence of participants in field work,

Be intellectually challenging, and

Give the participants some new skills in the use of a modern programable calculator.

To reach the objectives, the course was arranged to include the following parts:

Opening ceremonies,

Lectures by the course instructors,

Problem solving instruction by the course instructors,

Training in the use and programming of the HP 15C calculator,

Demonstration of the use of the TRS-80 Microcomputer,

Guest lectures by local Bangladesh experts, and others,

Field problems,

Field trips,

Reading assignments in the books, reports, papers, brochures, Lecture notes, and product data given to the participants,

Homework problems, on all parts of the course,

Course Evaluation Questionnaire,

Final Examination in two parts,

Presentation of diplomas and closing ceremonies.

SCHEDULE OF INSTRUCTION

During the first two weeks of the course, instruction was done on the following schedule, six days a week:

Lectures 8 to 9:30 a.m., 10 to 11:30 a.m. and 2 to 3:30 p.m. with a Computation Laboratory session 4 to 5:30 p.m. Field work was done in the mornings in place of classwork as needed to take advantage of the cooler part of the day.

During the last two weeks, at the request of the participants, another schedule was followed with continuous instruction or computation work from 7:30 a.m. to 1:30 p.m. except for one tea time.

Under the first schedule the day was broken into too many small parts and some time was wasted, but the participants were more alert on the average. Under the second schedule the participant seemed quite tired and inattentive by the end of the morning.

A compromise schedule would seem to be best if the course is repeated. Classroom lectures should be from 8 to 1 with one tea break and then a problem solving, homework, tutoring session from 2:30 p.m. to 4:30 p.m. with the instructors giving assistance as needed to the participants.

COURSE INSTRUCTION

Given by Dr. Calvin G. Clyde:

Introduction to Groundwater Hydrology
World Water Balance
Groundwater Use
Introduction to the H.P.15C Calculator
Calculator Laboratory - Statistics
Groundwater Occurance
Beginning Calculator Programming
Calculator Laboratory - Regression
Groundwater Exploration with Surface Geophysical Methods
Groundwater Movement: General Equations
Groundwater Mapping
Well Hydraulics: Steady and Unsteady States
Intermediate Calculator Programming
Well Functions on the HP 15C
Groundwater Hydraulics
Pump and Aquifer Tests
Image Wells and Well Interference
Analysis of Aquifer Test Data
Groundwater Quality
Groundwater Standards
Groundwater Pollution
Salt Water Intrusion and Its Control
Groundwater Fluctuations
Advanced Calculator Programming
Groundwater Planning and Management: Introduction
Step Pumping Test Analysis by Miller-Weber Algorithm on H.P.15C
Contouring Geohydrologic Data
Conjunctive Use of Surface Water and Groundwater
Economics of Groundwater Pumping
Alternative Yield Concepts

Salt Balance of Groundwater Basins

Artificial Recharge

Given by Tim Decker:

Geology and Aquifer Types, Porosity, Permeability

Well Drilling Techniques

Equipment for Measuring Groundwater Levels

Test Hole Drilling

Sieve Analysis

Well Design and Selection of Materials

Sites Selection, Gravel Pack Design

Pump Types, Motors and Equipment

Pump Hydraulics, Curves, Costs, Pump Selection

Diagnosis of Pumping Plant Problems

Well Efficiency, Corosion, Encrustation

Well Rehabilitation

Given by John Logan:

Geochemical Interpretations

Characteristics of the Three Groundwater Regimes: Introduction

The Confined Regime

The Unconfined Regime

The Leaky Aquifer Regime

The Hantush Inflection Point Method Demonstration

Shortcuts in the Computation of the Well Function

Practical Methods in Hydrogeology: I

Practical Methods in Hydrogeology: II

Use of Ternary Diagram in Geochemical Interpretations

Determining Mean Values of Contoured Data

Groundwater Investigations

Groundwater Management

Fundamentals of Programming in BASIC

Demonstration of a BASIC Program for Computing Drawdown

Groundwater Planning: I

Groundwater Planning: II

All instructors assigned homework problems related to their parts of the course and gave examples of how to solve them. Instructors also gave individual tutoring as needed.

H. P. 15 CALCULATOR PROGRAMS

Developed for and Demonstrated to the Course Participants:

Theis Well Function by Infinite Series Approximation: Beginning, Intermediate and Advanced Programs

Theis Well Function by Integration of the Exponential Integral (for large argument values)

The Inverse Well Function Evaluation (using SOLVE)

Pumping Test Analysis by the Jacob Straight Line Method with Least Squares fit of the line

Evapotranspiration by the Hargreaves ET, Equation

Drawdown at any point due to N Wells (or Image Well Systems)

Step Pumping Test Analysis Using the Miller-Weber-Algorithm

Using SOLVE to Find the Flow Rate for A Given Drawdown

Transit time (seepage) between Production and Injection Wells

Computation of Drawdown Curves in Confined Aquifer

GUEST LECTURES

Given by Local Bangladesh Experts:

"Geology and Geomorphology of Bangladesh" by Dr. Md. Anamul Huque, Assoc. Prof. of Geology, University of Dhaka (1 April).

"Irrigation Water Supply from Surface and Groundwater Sources in Bangladesh" by Dr. Shahjahan Kabir Chowdhury (2 April).

"Sources of Agricultural Production Growth in Water Sector" by Dr. M. A. Hannan, BUET (3 April).

"Groundwater Development near Comilla" by Mahibubur Rahman, Deputy Director, Agricultural Engineering, BARD, Comilla. Lecture given at Comilla (15 April).

"History of Groundwater Investigation and Development in Bangladesh" by M. A. Karim, BWDB (17 April).

"Utilization of Groundwater Resource in Bangladesh Agriculture" by Dr. S. M. Arshad Ali, Bangladesh Agricultural University, Mymensingh (paper presented by Dr. K. A. Haq, Member-Director, BARC) (24 April).

"Procedures for Measurement and Collection of Hydrogeological Data for Groundwater Investigations in Bangladesh" by Ghulam Mowla, BWDB (25 April).

"The Effect of Rainfall on Groundwater Recharge" by Dr. K. A. Haq, Member-Director, BARC (27 April).

"Soils of Bangladesh" by Dr. Z. Karim, PSO, BARI (27 April).

"Groundwater Modeling" by Dr. L. R. Khan, BAU (28 April). (Failed to show up to give the lecture)

Given by George Hargreaves, Director of Research, International Irrigation Center, Utah State University:

"Crop Water Requirements in Bangladesh" (6 April at BRRI)

"Factors Affecting Yield of Crops" (14 April at BARD, Comilla)

"Optimizing Yield of Crops" (15 April at BARD, Comilla).

FIELD PROBLEMS

On nine days during the course, part or all the time was spent in the field working on practical problems. The dates, time spent and description of the activities are given below:

4 April. 4 hours. Groundwater Mapping Data Collection.

Five methods of measuring the depth to groundwater were demonstrated; the chalked tape, the plopper (or whistle), the electrical wire-line, the bubbler tube and a newly developed electronic apparatus, the ultrasonic well sounder. The students were organized into teams of 4 or 5 and sent out to measure the depth to groundwater in two different wells for each group. The wells were production and observation wells located on the BRRI campus. Each student measured Water Levels in two wells by two different methods. The field problem then concluded with a measurement of depth to water by the use of a Signal Enhancement Seismic Refraction apparatus.

9 April. 5 hours, plus periodic measurements continuing for 4 more hours. Aquifer Pumping Test.

A constant discharge aquifer pump test was performed at a diesel driven production well. The well was shut in the preceeding evening to give the water level 12 hours to recover. The well was then pumped and water levels were measured at selected times in 6 monitor wells for 7 hours. Then the well was shut in and recovery of the W. L. in the monitor wells was monitored for four hours. The well discharge was measured by two methods - a cutthroat flume in the delivery ditch and an end-cap orifice meter on a pipe.

The following day the data were analyzed by the students to determine the aquifer constants .the transmissivity, and storage coefficient.

11 April. 5 hours. Pump Efficiency Test.

A pump efficiency test was performed on the same production well. Flow rate was measured with the end cap orifice. Water level in the well was measured with a wire-line. Delivery pipe pressure was measured with a stand-pipe. Input Horsepower was assumed from the diesel engine specifications. Output horsepower was calculated from the data and the efficiency of the pumping system was computed.

18 April. 2 hours. Groundwater Fluctuations.

The students were sent back to the same wells they had visited two weeks earlier to measure the water levels in the wells. The water level changes over the two weeks were then determined.

21 April. 2 hours plus continuing periodic measurements for 4 more hours. Step Pumping Test.

Flow rates were measured with an end-cap orifice and W.L. in the well by a wire-line. The well was shut in the night before and pumping began at 9:30 at 100 gpm. After one hour the W.L. was measured and the flow rate increased by 100 gpm. The process continued until 4 data points in the test had been obtained at 4 different pumping rates. From the data the well characteristics and the well efficiency were determined by a new program written for the H. P. 15C calculator.

FIELD TRIPS

14-16 April. Three days. Comilla and Noakhali.

The first day the group traveled by bus to the Bangladesh Academy for Rural Development near Comilla. After getting into the comfortable accommodations the group visited the nearby Mainamati archeological site and then heard a lecture by George Hargreaves on "Factors Affecting Yield of Crops". The evening was free for a visit to town. The next day visits to nearby shallow and deep tubewells was led by Mahibubur Rahman. Examples were seen of how farmers are lowering the STW pumps as the water levels recede. The DTW was observed to be pumping air and an instructive discussion dealing with remedial measures was led by Mr. Tim Decker. The group visited a site to see a hand operated cable tool drilling rig. In the evening Mr. Rahman, gave a lecture on "Groundwater Development near Comilla" and Mr. Hargreaves lectured on "Optimizing Crop Yields". The third day the group visited the BRRI field station at Noakhali. There the Director, pointed out some of the problems of salt and saltwater intrusion in the area and gave the group a much appreciated lunch. The group then returned to Comilla, stopping on the way to visit the new salt water control barrage across the Meghna river.

22 April. 4 hours. Visit to Drilling Site.

The class visited the site where a deep tubewell was being drilled by a reverse rotary drill rig. The drilling supervisor explained the process and answered questions. Refreshments were served and an invitation given to stay to lunch. Regretably the press of the class schedule prevented accepting the gracious lunch invitation.

MATERIALS DISTRIBUTED TO COURSE PARTICIPANTS

	Page
Calculator: H.P.-15C and Owners Manual	293
Textbooks:	
"Groundwater Hydrology" by David K. Todd, 2nd Ed.,John Wiley & Sons	535
"Improving Well and Pump Efficiency" by Otto J. Helweg, Verne H. Scott and Joseph C. Scalmanini; NWWA	158
"Groundwater Manual" by U.S. Bureau of Reclamation	480
"Basic Groundwater Hydrology" by Ralph C. Heath, USGS WSP 2220	84
Other Books and Reports:	
"Pumps and Water Lifters for Irrigation" Handbook No. 3 by Richard C. Griffin, G. H. Hargreaves, G.Z. Watters, R.K. Stuttler and L. Salazar.	160
"Well Drilling Manual" by Speedstar division of Koehring Company	75
"Application of Borehole Geophysics to Water-Resources Investigations" by W. Scott Keys and L. M. Mac Cary, U.S. Geological Survey.	126
"Crop Water Requirements for Bangladesh" by George H. Hargreaves and Zohrab A. Samani.	27
"Irrigation Water Distribution Systems for Tubewells and Low-Lift Pumps in Bangladesh" by Dan Jenkins, USAID.	62
"Groundwater Irrigation in Bangladesh: Development at the Crossroads" by Sadiqual I. Bhuiyan.	32
"Economic and Technical Operation of Deep Tubewells in Bangladesh" by Sam H. Johnsen, III BARC.	89
"Tubewell Project, North Bangladesh, Vol. 2, Groundwater" by Sir M. Malcolm MacDonald & Partners Ltd.	89
Papers and Brochures:	
"Review of Leaky Apresion Aquifer Test Evaluation Methods" by William C. Walter, Vol. 17, No. 3, GROUNDWATER.	14
"Interpretation of Electric Logs in Fresh Water Wells in Unconsolidated Formations" by R. P. Alger, Schlumburger Corporation.	24

* Not yet released from customs on 4/28/85.

"Modern Design Techniques for Efficient High Capacity Irrigation Wells" by J. W. Reinke and D. L. Kill, ASAE.	23
"Measurement of Water Flow through Pipe Orifice with free Discharge" by Layne & Bowler, Inc.	28
"Well Drilling and Completion"	40
"Rotary Sampling Techniques" by H. R. Barliff, Alsay Corp.	21
"PVC Pressure Pipe, 4 in-12 in, for Water" AWWA Ltd.	18
"How to Drill an Irrigation Well" by Irrigation Age.	30
"Johnson Drillers Journal" May-June 1979	15
Misc. Sales Literature and Product Data.	45
Lecture Notes on Borehole Geophysics and Surface Geophysics	15
Lecture Illustrations on Groundwater Fluctuations.	16
Homework Problems and Examinations.	28
Miscellaneous Data sheets and Field problems Data	12
Lecture Notes on Geochemistry and Soils	14
	2,500

LIST OF PARTICIPANTS

Course on "Groundwater Investigations" held at BRRI, Joydebpur, 1-28 April 1985

No.	Name	Discipline (Specialty)	Institution (Employer)
1	Mr. Md. Azharul Islam	Civil Engineer	BWDB
2	Mr. Aktar Hossain Khan	Agril. Engr.	BADC
3	Mr. Md. Abdus Sattar	Agril. Engg.	BRRI
4	Mr. Md. Abul Kalam Azad	Mech. Engr.	BADC
5	Mr. Ahmed Hossain Shah	Agril. Engg.	BWDB Thakurgaon
6	Mr. Md. A. Quddus	B.Sc. Engg (Civil)	BWDB
7	Mr. Abu Saleh Mohd Amanullah	Agril. Engg.	SRI (BSFIC)
8	Mr. Fariduddin Ahmed	Geologist	BWDB
9	Mr. Md. Harunur Rashid	Agril. Engg.	BARI
10	Mr. Jahangir Alam	Agril. Engg.	BARI
11	Mr. Md. Matiur Rahman	Mech. Engr.	BADC
12	Mr. Md. Mizanur Rahman	Agril. Engg.	BAU
13	Mr. Md. Muhsin Bhuiyan	Mech. Engr.	BADC
14	Mr. Md. Majibar Rahman	B.Sc. Agril. Engg.	BAU
15	Mr. Md. Mahfuzar Rahman	B.Sc. Agril. Engg.	BADC
16	Mr. Md. Nurul Islam	Agril. Engg.	BRRI
17	Mr. Md. Shirazul Islam	Agril. Engg.	BARI

Summary of Responses by 17 Participants

COURSE EVALUATION

[Circle the statement that most nearly express your opinion on each question]

1. For the time available for the course

a) Too much material was covered. (10)
b) Material covered was about right. (7)
c) Too little material was covered.

2. The course was

a) Too theoretical. (10)
b) A good balance between theory and practicality. (7)
c) Not theoretical enough.

3. The course involved

a) Too many example problems.
b) A good mixture of lecture and problems. (12)
c) Not enough example problems. (5)

4. The course had

a) Too much calculator instruction. (1)
b) A good balance between calculator and other work. (13)
c) Too little calculator instruction. (3)

5. The course included

a) Too much field work.
b) A good balance between classroom and field work. (7)
c) Too little field work. (10)

6. The trip to Comilla and Noakhali was

a) Very worthwhile.
b) Some what worthwhile. (8)
c) A waste of time. (9)

7. The quality of the guest lectures was

a) Excellent. (1)

b) Good. (14)

c) Poor. (2)

8. The course was

a) Stimulating professionally. (2)

b) Helpful professionally. (14)

c) Not of much use professionally. (1)

9. The quality of instruction was

a) Excellent. (4)

b) Good. (13)

c) Poor.

10. Suggest topics that should be added to the course.

Solve more G.W. Problems in the classroom (5)
More Field Problems (4)
More Calculator Programming (1)
More Groundwater Modeling (1)
More Well/pump Efficiency (1)
More Well Design/Development (1)
More Water Budget Details (1)
More Salt Water Intrusion Details (1)
More G.W. Recharge Calculations (1
Soil-Water-Plant Topics (1)
No more Topics Needed (1)
More Groundwater Management (1)

11. Suggest topics that should dropped from the course.

No Topics should be dropped (1)
Micro-Computer topics (1)
Land-Drainage (1)
Remote Sensing (1)
Leave out theory not adaptable to Bangladesh (1)

12. Please suggest ways to improve the course.

Make course longer to allow time for follow-up and more applications (6)
Course should be more oriented to field work (6)
Course should be more practically oriented (5)
More in-country guest lecturers (2)
Invite guest lecturers with field experience (2)
Improve the guest lectures (1)
Course should be more theoretical (1)
More help needed from instructors (1)
Solve more Bangladesh example problems (1)
More field trips to
Groundwater Problem areas (1)
Improve management and Coordination (1)
Shorten the course (1)
Improve the accommodations (1)
Have quizes partway thru course

SUGGESTIONS FOR COURSE IMPROVEMENT

Schedule:

Follow the revised schedule suggested in an earlier section.

Facilities:

Find a better classroom that can be darkened to show slides.

Field Trips:

Cut the trip to Comilla to two days and don't try to visit the salt water area.

Field Work:

Increase the field problems by the time saved on field Trips. The instrumentation and facilitates for the pumping tests should be improved as follows:

1. Release water some distance away from the wells during the pumping test by laying temporary piping.
2. Improve the measurement of flow rate.
3. Install one or two automatic recorders on observation wells for give fast response in the early parts of the tests.
4. Do the pump efficiency testing or an electric driven well so wire-to-water efficiency can be determined.
5. Obtain in advance good maps of the BRRI/BARI area with all wells located and ground surface elevations given at each well. This will allow the construction of W. L. contour maps and charge maps as a class exercise.
6. Give demonstrations of resistivity tests and downhole well logging. This could not be done this time because the equipment was never released by customs.

Homework

Doing the homework assignments should be mandatory as should attendance at the problem solving sessions. The voluntary homework procedure used this time did not force the students to get the problem solving practice that they needed.

Prior Committment to the full work schedule:

The participants should come to the course mentally prepared for and committed to the idea of spending long, intense days working at the course.

Course Materials:

Books, materials and equipment needed for the course should not be shipped but should be brought over by the course instructor as luggage.

EVALUATION OF PARTICIPANTS

The performance of the participants was evaluated by giving six hours of examinations the last two days. The exam. questions are given in the appendix.

Participant No. 9 did excellent work in the course and scored significantly higher thaan anyone else.

Participants 1, 3, 4, and 13 did very well.

Participants 12, 11, 14, 15, 17, 2 and 16 did good work.

The other participants ranged from satisfactory to marginal.

All the participants made substantial progress in learning to effectively use their HP 15C calculators.

A P P E N D I X

INSTRUCTORS

Dr. Calvin G. Clyde
Professor of Civil Engineering
Utah Water Research Laboratory
Utah State University 82
Logan, Utah 84322

Mr. Tim Decker
Consulting Hydrogeologist
62331 Verde Road
Montrose, Colorado 81401

Mr. John Logan
Consulting Hydrogeologist
P.O. Box 2096
Carmel, California 93921

1/8

Name: _____

Closed Book

Groundwater Investigations

Part I of Final Examination

1. Briefly define and give examples of:

   a) Primary porosity:

   b) Secondary porosity:

2. List two categories of aquifers and give examples of how and where each might occur in Bangladesh.

3. Define "piezometric surface" and tell what controls the elevation of the piezometric surface.

4. Name the two general categories of drilling techniques and give two example methods in each category.

v/8

Closed Book

5. Which drilling techniques would be best to use in Bangladesh for a 500 ft. deep test hole? Why?

6. List three purposes of the "drilling mud" used in rotarv drilling.

7. Name four of the most useful geophysical bore hole logs for water wells in Bangladesh.

8. True or false.

   a) Neutron logs measure porosity.

   b) Density logs measure grain size.

   c) Caliper logs measure well depth.

3/8

Open Book

9. What is the practical minimum borehole and casing diameters for test hole drilling and sampling?

10. Calculate the open area (in sq. inches and %) for a 12 inch diamter slotted pipe with slots that are 1/6 inch by 4 inches and 20 slots per foot with a total slotted length of 20 ft.

11. Calculate the open area (in sq. inches and %) for a wire wrapped screen with slot size = 0.0625 inches and a wire width = 0.090 inches and a total length of 20 ft.

12. What is accepted as the maximum entrance velocity thru slots? Give three reasons for your answer.

4/8

Open Book

13. For questions 10 and 11, calculate the maximum transmitting capacity at the maximum recommended velocity.

14. Calculate the Ryznar Stability Index for the following water:

a) TDS = 1250 mg/l

Ca = 25 mg/l

Mg = 15 mg/l

Na = 40 mg/l

Hardness = 50 mg/l

Fe = 0.05 mg/l

pH = 7.1

SO_4 = 150 mg/l

Alkalinity = 150 mg/l

b) What type(s) of material would be appropriate for a well screen in this water?

c) Is the water corrosive, encrusting, both, or benign? Why?

24

5
5

Open Book

15. Given the attached grain size distribution curves and other data:

a) Design a 225 gpm well, 100 ft. deep.

b) Design a 900 gpm well, 150 ft deep.

Note: To design a well means to select.

1) Casing Diameter
2) Slot and/or gravel pack size
3) Length of screen
4) Depth of screen placement
5) Diameter of borehole
6) Diameter of screen

16 For the data of problem 15.

a) Calculate T for each interval
   1) 80 to 100 ft.
   2) 100 to 130 ft.
   3) 130 to 150 ft.

b) Estimate theoretical maximum specific capacity for
   1) Well 15a - screened interval
   2) Well 15b - screened interval

Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc

SAND ANALYSIS
(FINE)

MAILING ADDRESS: P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

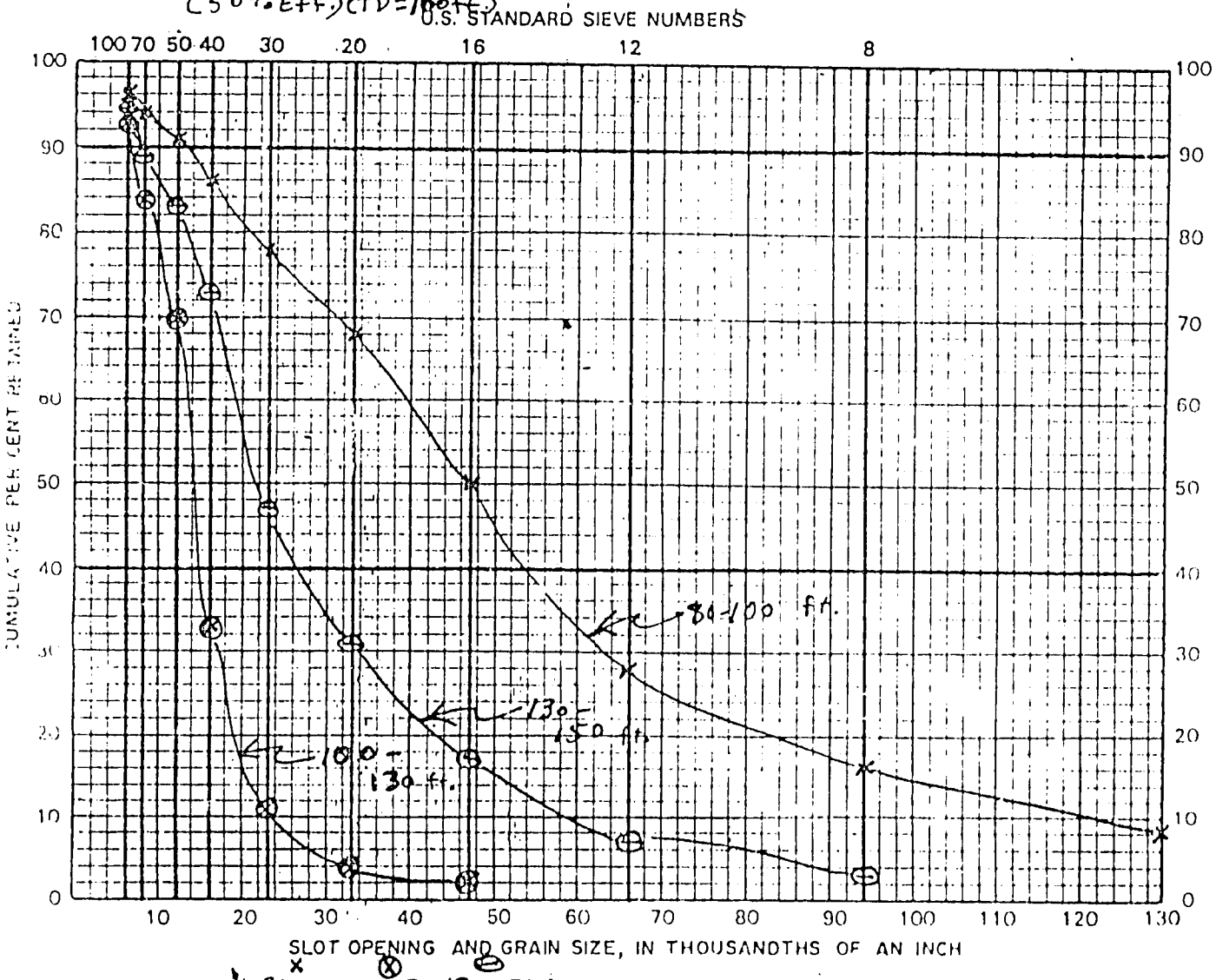
Data for Problems 15 and 16

Sample sent in by BRRI.

Town Joydepur State Zip Date 4-14/85

From well of BRRI Farm Test Hole # 6c.

Remarks: 4" Rotary hole; bentonite mud; S.W.L. = 40'; specific capacity test = old well = 85 gpm/ft; Laboratory permeability conducted (see below graph) (50% Eff.) (TD = 100 ft.)



× 80-100 ⊗ 100-130 ⊖ 130-150 ft.

U.S. SIEVE NO	SIEVE OPENING INCHES	SIEVE OPENING MM	CUMULATIVE % RETAINED		
6	.132	3.36			
8	.094	2.38			
12	.066	1.68			
16	.047	1.19			
20	.033	0.84			
30	.023	0.60			
40	.016	0.42			
50	.012	0.30			
70	.008	0.21			
100	.006	0.15			

(gpd/ft²) LAB. K = 750. 200 350

Notes:

Recommended Slot Opening

Recommended Screen Dia in. Length Ft

By

SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOT SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF JOHNSON WELL SC ... S.

UOP 14-3155

7/8 Open Book

17. a) List four reasons for incrustation of a well screen and describes appropriate treatment methods.

b) Name four effective methods of development (or redevelopment) to increase yields.

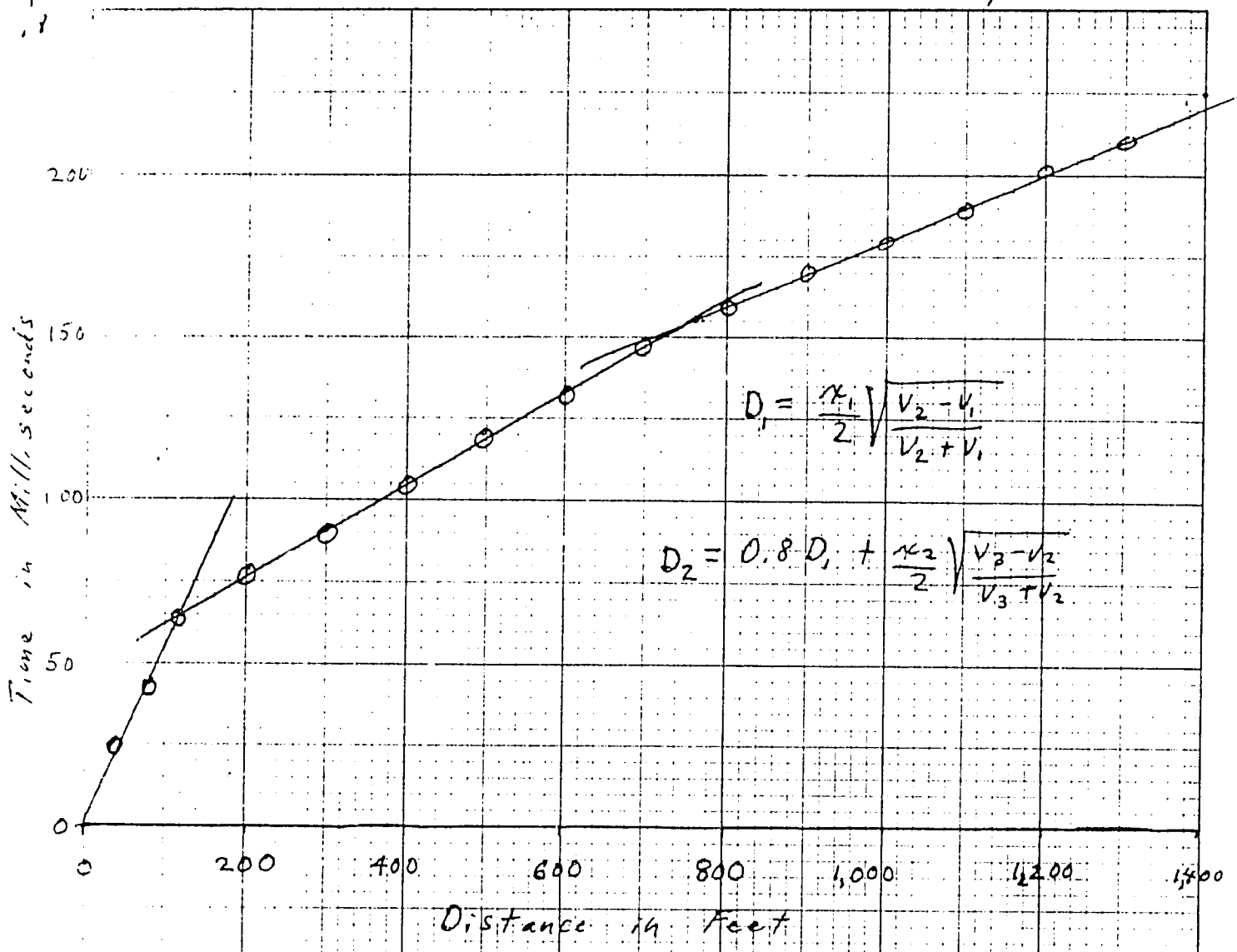
18. Explain what is meant by GIGO.

19. Even though well design is a complex art and skill, what does the "Decker Rule-of-Thumb, KISS, mean?

20. a) Describe how to find a horizontal boundary by a surface resistivity test.

b) A vertical boundary.

2~~0~~. Data from a seismic retraction test are plotted below.



(a) Determine the velocities of sound in the three layers indicated by the test

(b) Find the depths of each layer

c. Give an interpretation of the conditions revealed by the test.

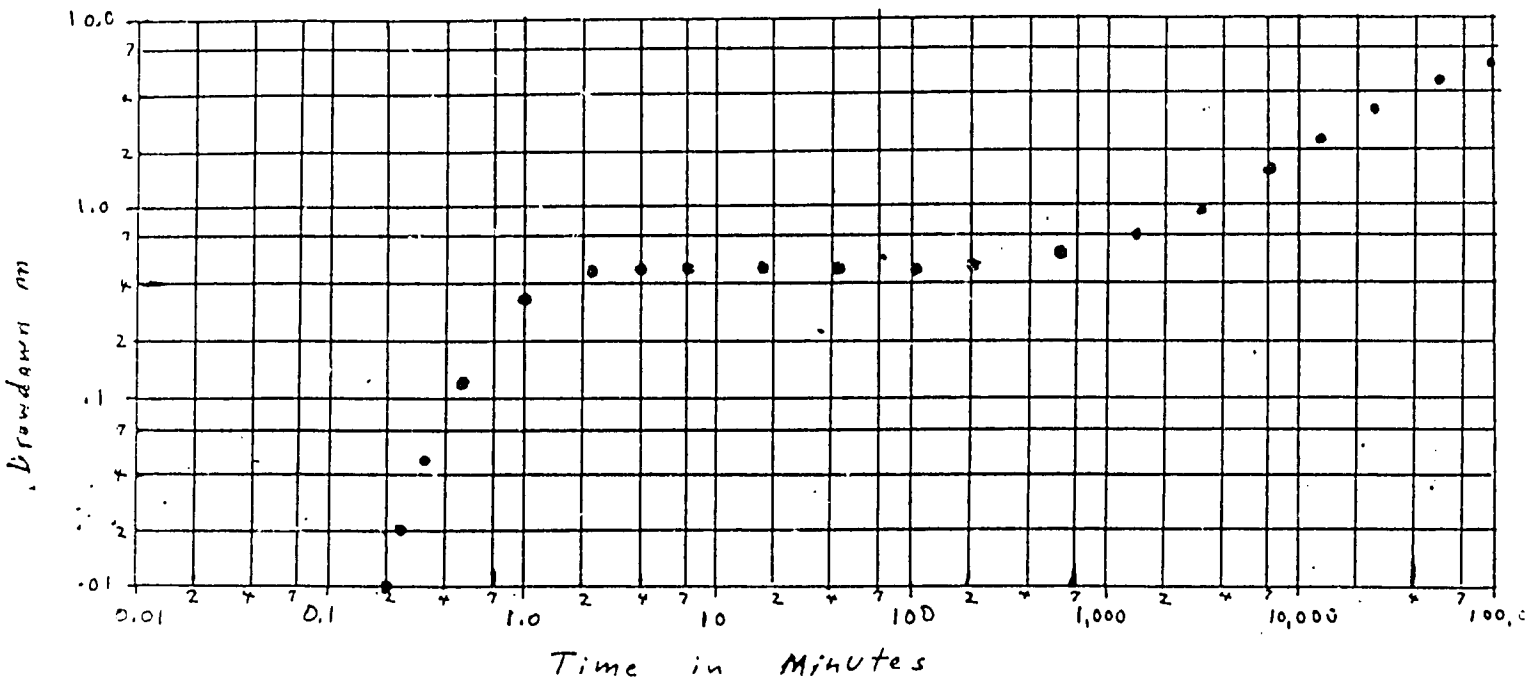
Name: _____

Open Book

Groundwater Investigation

Part II of Final Exam.

1. A pumping test is done in an unconfined, fully penetrating aquifer by pumping for 70 days from a production well at 3 m^3/min. while recording the drawdown in an observation well 80 m. from the production well. The data is plotted below. Find T, Sa, Sy and thickness M.



[A type curve is available from the instructor]

Open Book

2. A confined aquifer 30 m. thick is 100 m. below the ground. Porosity = 35%. Barometric efficiency is 40%. Compressibity of water is 20,000 kg/cm^2. Specific gravity of Mercury=13.6

a) If the barometric pressure goes from 753 mm to 746 mm of Mercury, how much and in what direction would the water level in a well move?

b) What is the storage coeficient of the aquifer?

c) What part of the storage is due to water expansion and what due to aquifer compression?

3. Data from a Water sample chemical test:

Ion	mg/l	Conversion Factor
Ca	50	0.050
Mg	125	0.082
Na	830	0.044
K	40	0.026
HCO_3	270	0.016
SO_4	260	0.021
Cl	1,390	0.028
NO_3	50	0.016

a) Is the sample analysis complete?

b) What is the % sodium?

c) Is the water suitable for irrigation?

d) What is the likely source of the G.W.?

30

Open Book

2. A confined aquifer 30 m. thick is 100 m. below the ground. Porosity = 35%. Barometric efficiency is 40%. Compressibity of water is 20,000 kg/cm^2. Specific gravity of Mercury=13.6

a) If the barometric pressure goes from 753 mm to 746 mm of Mercury, how much and in what direction would the water level in a well move?

b) What is the storage coeficient of the aquifer?

c) What part of the storage is due to water expansion and what due to aquifer compression?

3. Data from a Water sample chemical test:

Ion	mg/l	Conversion Factor
Ca	50	0.050
Mg	125	0.082
Na	830	0.044
K	40	0.026
HCO_3	270	0.016
SO_4	260	0.021
Cl	1,390	0.028
NO_3	50	0.016

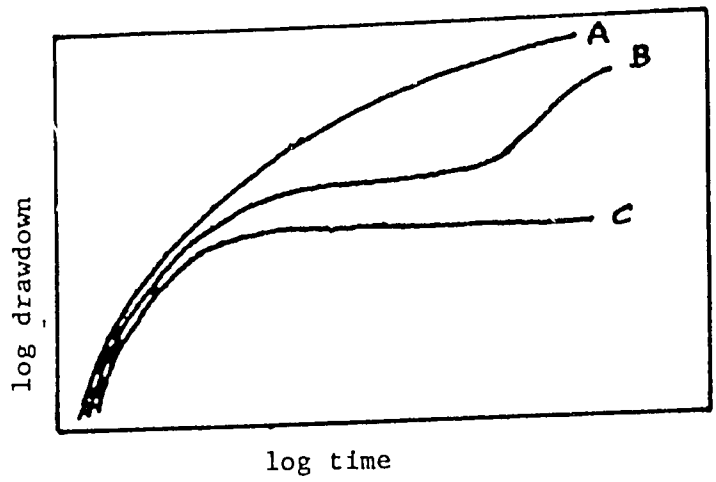
a) Is the sample analysis complete?

b) What is the % sodium?

c) Is the water suitable for irrigation?

d) What is the likely source of the G.W.?

Closed Book



a) In the sketch above, what hydrologic condition is indicated by each of the curves in the absence of disturbing effects?

A_____

B_____

C_____

b) Identify two possible effects that might disturb or modify the type curves shown in the sketch:

5. What is meant by "twt"?

6. For semiconfined ("leaky") aquifers, what is the advantage of the Hantush inflection-point analysis over the Hantush-Cooper type-curve analysis?

Closed Book

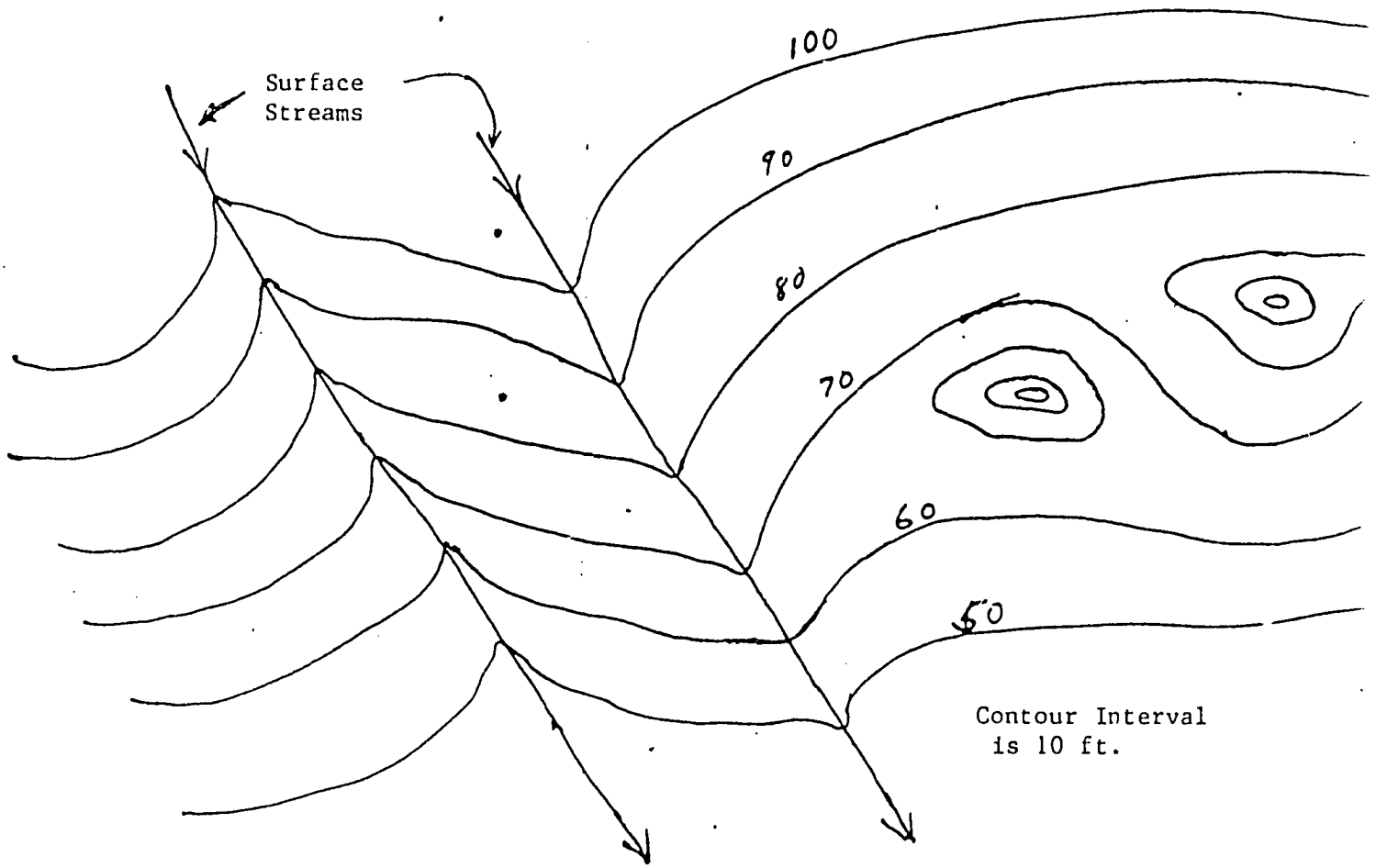
7. On the Groundwater contour map below, identify the following:

a) Gaining stream

b) Losing stream

c) Recharge area

d) Pumping center



8. Define specific (or intrinsic) permeability. What are its units?

9. Define ~~maximum perennial yield~~ "Anisotropic Aquifer"?

37

Closed Book

10. What are the methods of artificial recharge commonly used in groundwater management? Mark with a ✓/ those which are appropriate for use in Bangladesh.

11. Describe the methods for managing (controlling) seawater intrusion in a coastal aquifer. Which methods can be used in Bangladesh?

12. List 10 causes of fluctuations in groundwater level.

Closed Book

13. Describe how the direction of movement of Pollution can be predicted.

14. What is meant by a "groundwater standard"?

15. On our visit to the drilling site you saw some bamboo "centralizers". Describe what those centralizers were to be used for?

16. On the visit to Comilla we visited a well whose discharge visibly surged or fluctuated. What was wrong with the well? How did we diagnose the problem. What should be done about it?

Closed Book

17. On the visit to Noakhali we learned that usually pump salty water. Deeper wells (to 30 ft.) have been good. as 900 ft.)

a) What quality water would likely be produced by a very deep well (> 2000 ft.) Why?

b) What is the source of the shallow salty groundwater?

18. What <u>three</u> different kinds of pumping tests did the class perform in the field? What was learned from each different test?

19. Explain what is meant by "salt balance" of an irrigated area?

Closed Book

20. Describe the steps you should go through to prepare (write) a program for your calculator.

21. During the course you heard 8 guest lecturers from Bangladesh. Name three of them.

22. Describe what is meant by "maximum perennial yield".

Closed Book

23. Major alternates of water development in Bangladesh include:

a) Restrict ground-water pumping to a depth of about 6 m. to protect existing STWs and HTWs;

b) Encourage deeper pumping in order to use the maximum amount of recharge;

c) Delay a decision on (a) or (b) until additional surface-water supplies can become available in boro season.

Which one do you favor? Why? If you have a better alternate, describe it.

24. The cost of a tubewell in TAKA is $C = 30a\,D^n$ where a and n are constants and D is depth in meters. Write a program for the H.P. 15C to compute C for any a, n, and D. Store a, n, D in Reg. 1, 2, Store C in 0. Load the program and Compute C for (1) D = 150 m., a = 1140, n = 0.299
(2) D = 450 m., a = 1100, n = 0.48.

25. Given $s = 0.0135\,Q + 0.0000412\,Q^{1.88}$
Using the "SOLVE" key on the calculator, find Q for s = 16 m. [Q is in m^3/day]

ADDITIONAL BARC PUBLICATIONS

ON

IRRIGATION WATER MANAGEMENT

The following publications are available upon request to the IWM Program Area IADS/BARC.

BARC. Soils-Water Management Research Inventory and Problems in Bangladesh. 1979.

Oswal, M. C. Soil and Water Management Program for Bangladesh. BARC. July 1979.

Brammer, H. Ploughpans and Tillage Problems in Bangladesh Soils. BARC. March, 1980.

Siddique, A. B. and C. Pray. Survey of Irrigated Cropping Patterns in Bangladesh and Implications for draft SFYP. A/D/C - BARC. November 1980.

Khan, M. R. and M. A. Rahman. Water Requirement of Cotton for Optimum Yield under Different Cultural Practices. First Annual Project Report. BARC. June 1981.

BARC. Inventory on Manpower and Physical Facilities Available for Irrigation and Water Management Research in Bangladesh. Soils and Irrigation Division. November, 1981.

Karim, Z. et al. Coastal Saline Soils and their Management in Bangladesh. BARC. January, 1982.

Levine, Gil. Irrigation & Water Management. BARC/IADS Consultancy Report. February, 1982.

Lowdermilk, Max. Final Report on Consultation (Water Management). BARC/IADS Consultancy Report. March, 1982.

BARC. First Annual Report: Coordinated Irrigation and Water Management Extension Specialist at BARC. BARC/IADS Consultancy Report. October, 1982.

Bisselquist, David. Proposed Activity for IADS Water Management Extension Specialist at BARC. BARC/IADS Consultancy Report. October, 1982.

Johnson, Loyd. Proposed Water Management Activities Report for BARC/IADS Agricultural Engineer. BARC/IADS Consultancy Report. November, 1982.

Karim, Z. and N. A. Ahmad. Net Irrigation Requirement of Rice and Evapotranspiration of Wheat and Potato for Different Locations of Bangladesh. BARC. December, 1982.

Hanratty, Martin. Minor Irrigation Development in Bangladesh. USAID/Bangladesh. April, 1983.

Johnson, Lloyd. Observations on Water Management Issues in Bangladesh. BARC/IADS Consultancy Report. May, 1983.

Ghani, A. et al. Collection of Different Types of Manually Operated Pumps Available in the Country and Evaluation of their Performances in Order to Select the Best Available Design to Carry Further Modification, if Necessary, to Improve Performance. Ag. Engineering. Research Report No. 7. July, 1983.

Levine, Gil. Water Management Workshop. BARC/IADS Consultancy Report. August, 1983.

BARC. Second Annual Report: Coordinated Irrigation and Water Management Studies (1981-82). Soils and Irrigation Division. September, 1983.

Walter, Michael & others. Review of Irrigation Water Management Program at Bangladesh Agricultural University, Mymensingh. BARC/IADS Consultancy Report. October, 1983.

Radosevich, George E. Groundwater Development and Management in Bangladesh: Institutionalizing a Strategy. BARC/IADS Consultancy Report. November, 1983.

BARC. Priorities for Research in Irrigation and Water Management. Soils and Irrigation Division. December, 1983.

Howes, Richard B. Options in Powering Irrigation Equipment for Tubewells and Low-lift Pumps in Bangladesh. BARC/IADS Consultancy Report. December, 1983.

Gill, Gerard J. The Demand for Tubewell Equipment in Relation to Groundwater Availability in Bangladesh. BARC Agricultural Economics and Rural Social Science Papers No. 13, 1983.

Weaver, Thomas et al. A Framework for Economics Research on Water Management in Bangladesh. BARC/IADS Consultancy Report. January, 1984.

Radosevich, George E. Water Law Bibliography for Bangladesh. BARC/IADS Consultancy Report. January, 1984.

Blevins, Robert L. Potential for Minimum Tilage in Bangladesh. BARC/IADS Consultancy Report. February, 1984.

Johnson III, Sam. Economics and Technical Operation of Deep Tubewells in Bangladesh. BARC/IADS Consultancy Report. March, 1984.

Chaudhuri, S. D., A. Ali, M. A. Ahmed. 1983 Internal Review of BARC's Irrigation Water Management Research Program. April, 1984.

McConnen, R. J., D. C. Slack, I. H. Khan and M. N. Haq. 1984 External Evaluation Report of Irrigation and Water Management Program. July, 1984.

Emmert, J. P. Equity Issues in Irrigation in Bangladesh: A Comparative Discussion of Technologies, Organization, and Support Services. BARC/IADS Consultancy Report. August, 1984.

Chawdhuri, S. D. and David Gisselquist. Command Area Development for Minor Irrigation: Integration of Organizational, Economic, Agronomic, Engineering, and Institutional Components. December, 1984.

Carson, Bill. Debiganj Irrigation System Master Plan. BARC/IADS Consultancy Report. January, 1985.

Howes, Richard R. A Suggested Approach to Model Use and Development at the Bangladesh Agricultural Research Council. BARC/IADS Consultancy Report. March, 1985.

Johnson, III, Sam. Economic and Technical Criteria for Location of Deep and Shallow Tubewells. BARC/IADS Consultancy Report. April, 1985.

Johnson, Jane S. Data Base Management at BARC: Applications for Documentation and Administration. BARC/IADS Consultancy Report. April, 1985.

Dalsted, Kevin. Use of Remote Sensing for Agricultural Research in Bangladesh. BARC/IADS Consultancy Report. April, 1985.

Hargreaves, George. Irrigation Water Production Functions: Report on a Training Course. BARC/IADS Consultancy Report. April, 1985.

Clyde, Calvin G. Groundwater Investigations: Report on a Training Course. BARC/IADS Consultancy Report. April, 1985.

Sandhu, Ghulam Rasool. Assessment of Saline Soils Research. BARC/IADS Consultancy Report. April, 1985.

Ali, Arshad S. M. 1985 Internal Evaluation Report: Water Management Program Area of ARP II. BARC/IADS Consultancy Report. April, 1985.

DISTRIBUTION OF REPORT

Ministry of Agriculture

Secretary,
Agriculture and Forests Division

Secretary, Irrigation Water
Development and Food Control
Division

Ministry of Finance

Secretary

BARC

Chairman
Member-Director (AESS)
Member-Director (Crops)
Member-Director (Livestock)
Member-Director (A&F)
Member-Director (Forestry)
Member-Director (Ag. Engg.)
Member-Directot (S&I)
Member-Director (P&E)
Director (Training)
Director (Administration)
NALDOC - 3 copies

IADS

Dr. D.S. Athwal, Arlington - 10 copies
Library, Arlington - 2 copies
Project Supervisor/Adviser
Water Management Specialist
Water Management Extension Specialist
Agricultural Engineer

USAID

Washington, D.C. - 10 copies
Dhaka, Food and Agriculture
Division - 3 copies

IRRIGATION WATER MANAGEMENT PROGRAM AREA
MAILING DISTRIBUTION LIST

1. Mr. Dan Spare
c/o United Mission to Nepal
P.O. Box 126
Kathmandu, Nepal

2. Dr. Robert Chambers, IDS
University of Sussex
Brighton, BN 1 9RE
England

3. IRWP Office, 5/7 Lalmatia
Block 'B', Dhaka

4. Team Leader SSISP
Coode & Partners
PO Box 3128, Dhaka - 2

5. Project Director
Small Scale Irrigation Sector Project
Planning Schemes - II (ADB), BWDB
47, Mirpur Road, Dhaka - 5

6. Md. Mosharraf Hossain
Agro-Economic Research Unit
Agriculture & Forest Division
Room No. 502 (middle Block)
Khamar Bari, Dhaka

7. Md. Abdus Samad
Library, Agro-Economic Research Unit
AFD, Ministry of Agriculture
Khamar Bari (Middle Block)
5th Floor, Krishi Khamar Sarak, Dhaka

8. Chairman, BWDB,
WAPDA Building (2nd Floor)
Motijheel C/A, Dhaka

9. Dr. Anwarullah Chowdhury
Associate Professor
Dept. of Sociology
Dhaka University

10. D.N. Moore (Sir M MacDonald & Patners)
Intensive Rural Works Programme
(Water Resources Cell)
L.G.E.B, 5/7, Lalmatia
Block - B, Dhaka - 7

11. S. M. Ali Imam
Superintending Engineer (STW)
BADC, Laxmipur, Rajshahi

12. Yin Au-Yeung
PRC Engineering
1551 East Mineral Place
Littleton, Colorado. 80122
USA

13. S. M. Hossain Saif
PSO (Agril. Engg.)
BARC, Farm Gate, Dhaka

14. Md. Abdus Sattar
Agril. Engg. Division
BRRI, Joydebpur

15. Md. Jahirul Islam
SSO, Agril. Engg. Division
BRRI, Joydebpur

16. S.M. Nazim Uddin
Agril. Engg. Division
BRRI, Joydebpur

17. Mr. Atti Yliverronen,
Administrator RDRS
Rangpur Dinajpur Rehabilitation Service
PO Box 618, Ramna, Dhaka - 2

18. Mr. Charles J Fluegel/Director
RDRS, PO Box 618, Ramna, Dhaka - 2

19. Md. Elias
SO (Potato)
Breeders Seed Production Centre
Debiganj, Panchagarh

20. M. Ikramullah
Project Manager
Mirpur Agril. Workshop & Training School
Mirpur Section 12, Pallabi, Dhaka - 16

21. Md. Ruhul Amin
SO (Ag. Engg.)
Breeders Seed Production Centre
Debiganj Panchagarh

22. James E. Haldeman
International Agriculture Program
Cornell University
384 Coldwell Hall
Ithaca, New York 14853, USA

23. S. H. Mawly
World Bank,
PO Box 97, Dhaka

24. Dr. Syed Fazle Elahi
Associate Professor,
Dept. of Soil Science
Dhaka University

25. Md. Shawkat Ali Mallik
Sr. Scientific Officer
Soil Physics Section,
BARI, Joydebpur

26. Md. Shafiqul Islam
SO (Soil Physics)
BARI, Joydebpur

27. Md. Mainur Rahman
PSO (In charge)
Soil Physics Section
BARI, Joydebpur

28. Mr. B.C. Basak
BINA, PO Box 4,
Mymensingh

29. Library
Institute of Flood Control &
Drainage Research
BUET, Dhaka

30. Dr. A. Nishat
Director, IFCDR,
BUET, Dhaka

31. Mr. Walter Kock
Senior Agriculturist
World Bank
222 New Eskaton Road, Dhaka

32. Mr. Anthony Bottrall
Program Officer
Ford Foundation
PO Box 98, Dhaka

33. Dr. H. R. Khan
Northwest Hydraulic Consultants
SE(F) 1, Gulshar Avenue, Dhaka

34. Dr. Keith Pitman
Consultant Hydrogeologist
HARZA/MPO, House 96/A,
Road 23, Banani, Dhaka

35. Dr. H.P. Hyland
Dy. Resident Representative
UNDP, Road 11A, House 60,
Dhanmondi, Dhaka

36. Dr. A. Hannan, Professor
Dept. Water Resources Engineering
BUET, Dhaka

37. Dr. S. M. Arshad Ali
Dept. of IWM
BAU, Mymensingh

38. Head, Engineering Division
BRRI, Joydebpur

39. Dr. Z. Karim, PSO
Soil Science Division,
BARI, Joydebpur

40. Dr. Gil Levine
Program Officer
Ford Foundation
55 Lodi Estate
New Delhi 110003, India

41. Dr. S.I. Bhuiyan, Head
Dept. of IWM,
IRRI, PO Box 933, Manila,
Philippines.

42. Mr. H. Rashid,
PSO, Ag. Engg. Division.
BARI, Joydebpur.

43. Mr. N.A. Akhand,
PSO, S&I Division,
BARC, Dhaka.

44. Dr. Jacob Rosing,
Chief Technical Advisor
Planning Cell,
New Secretariat Building Room 420,
Bangladesh Secretariat, Dhaka.

45. Mr. Keith H. Dorey
Chief Technical Adviser
Rural Development Academy
Sherpur, Bogra

46. Dr. M.K. Haque, Head
Dept. of IWM
BAU, Mymensingh

47. Dr. L. R. Khan
Dept. of IWM
BAU, Mymensingh

48. Prof. M.R. Biswas
Dept. of IWM
BAU, Mymensingh

49. Dr. S. Talukder,
Dept. IWM
BAU, Mymensingh

50. Dr. M.A.S. Mandal
Agricultural Economics Dept.
BAU, Mymensingh

51. Prof. Idris,
Soil Science Dept.
BAU, Mymensingh

52. Dr. Dave Schuy,
Economist, MPO
House No. 96/A, Road 23,
Banani, Dhaka.

53. Dr. Tony Garvey
Project Supervisor, MPO
House No. 96/A,
Road 23, Banani, Dhaka

54. Mr. A.T.M. Aminul Islam
Chief Engineer (Planning)
MPO, House No. 96/A, Road 23
Banani, Dhaka

55. Dr. Risto Harma
World Bank
222 New Eskaton Road
Dhaka.

56. Dr. Amjad Hossain
Project Coordinator
Rural Development Academy
Sherpur, Bogra

57. Mr. Nazmul Alam
Member Director (Irrigation)
BADC, Krishi Bhaban,
49-51 Dilkusha C/A, Dhaka

58. Mr. A.A. Asadullah,
Chief Extension Officer
BWDB, Motijheel C/A, Dhaka

59. Dr. Edwin B. Dyer
Director
International Agricultural Program
Cornell University
Ithaca, N.Y. 14853, USA

60. Mr. Timothy Kelley
Ag. Economics Dept.
Cornell University,
Ithaca, N.Y. 14853
USA

61. Dr. Donald Slack
Soils, Water & Engineering Dept.
University of Arizona,
Tucson, Arizona, 85721
USA

62. Dr. Richard J. McConnen
Professor Ag. Economics
Montana State University
Bozeman, Mon. 59717, USA

63. Prof. Serajul Islam
Professor of Rural Economics,
Institute of Bangladesh Studies,
W23B, University Quarter
Rajshahi University
Rajshahi.

64. Dr. W. A. Garvey
Team Leader
MPO/HARZA
House # 96, Road # 23 A
Banani, Dhaka.

65. Dr. M. Mosleh Uddin
Associate Professor
Department of Statistics
Dhaka University
Dhaka-2.

66. Mr. A. F. Bottrall
Program Officer
Ford Foundation
P.O. Box # 98
Ramna, Dhaka-2.

67. Gunnar Knutsson
First Secretary
(Development Corporation)
IRWP Office
5/7, Lalmatia
Block 'B
Dhaka.

68. Mr. Pijush Kanti Sarkar
Scientific Officer
Agril. Engg. Division
BARI, Joydebpur,
Gazipur.

69. Dr. Muinul Islam
Associate Professor and Chairman
Department of Economics
University of Chittagong
Chittagong.

70. Librarian, MPO
Ministry of Irr. Water Dev. &
Flood Control
Master Plan Organisation
House # 96, Road # 23,
Block - A, Banani,
Dhaka.

71. Programme Officer
(Agriculture/Rural Development)
Sewdish Embassy
G.P.O. Box 304
Dhaka.

72. Mr. Nicanor C. Austriaco, D. Eng.
Director, Continuing Education Center
Asian Institute of Technology
P.O. Box 2754
Bangkok
Thailand.

73. Mr. Nasir Uddin Ahmad
Assistant Professor
Department of Economics
Chittagong University
Chittagong.

74. Mr. Leslie Small
International Irrigation
Management Institute
IIMI
Digana Village
Via Kandy
Sri Lanka.