WASH

MEMORANDUM

TO: K. Kawata, NE
J. Grayzel, NE
F. Pollock, USAID/Cairo
W. Twyford, USDA Graduate School

FROM: Fred Rosensweig

SUBJECT: BVS Overseas Training

DATE: October 30, 1984

I am pleased to send you a copy of the training design for the WASH component of the BVS overseas training program. The attached represents the training guide which the trainers will use in conducting the course. We will send to you shortly the participants' manual and a list of materials which we are providing to the participants.

93|1176
PN-AAU-727
IAN-44476

Water and Sanitation for Health Project

A COURSE DESIGN FOR BASIC VILLAGE SERVICES (BVS) TRAINING IN:

- o Water Supply
- o Groundwater and Wastewater
- o Maintenance

TRAINER GUIDELINES

Prepared under Order of
Technical Direction No. 191

Prepared by:
Jonathan French
Joseph Haratani
James Jordan
John Pettit

October, 1984

AID/DSPE-C-0080

OVERVIEW AND GOALS OF COURSE

The purpose of this technical component of the Basic Village Services (BVS) training course is to provide participants an opportunity to improve their skills in designing, implementing, and maintaining local public water supply and wastewater systems. Planning, constructing, and maintenance of these systems is the primary theme. This set of trainer guidelines is intended to be used by the trainers who will conduct the training. It is not a guide for participants. A separate participants manual contains the materials which will be given to them.

This five week course of technical training is part of a ten week program for engineers who are responsible for the design and maintenance of BVS village projects.

The overall course objectives describe what participants will be covering in each of the technical areas and during the sessions devoted to the process simulation. The course schedule at the end of this section shows how the days are structured to achieve these objectives.

Water Supply

1. To review the nature of hydrologic flow with respect to water supply and groundwater flow in the Nile delta area.
2. To examine how water supply systems are planned, developed, operated, and maintained.

3. To determine appropriate water quality criteria, testing procedures and treatment processes.
4. To review basic pipeline hydraulics and practice using calculations for hydraulic network analysis.
5. To examine the procedures to be carried out in groundwater site selection, well installation, and prevention of contamination.

Groundwater and Wastewater

1. To examine the three stages of the groundwater cycle.
2. To describe and discuss the causes of high phreatic groundwater and the problems resulting from it.
3. To develop practical methods for controlling high groundwater levels.
4. To demonstrate a methodology for designing a simple sewerage network.
5. To explore the advantages and disadvantages of the ways to dispose of excess groundwater.
6. To examine various treatment alternatives for wastewater.

Maintenance

1. To examine the effects of good and poor maintenance.
2. To establish those elements which are an essential part of a good maintenance program.
3. To determine how proper maintenance will extend the life of a facility and its equipment for many years.
4. To develop a flow chart of the steps for a preventive maintenance program that could be applied to typical BVS projects.

5. To establish the needs of a maintenance unit in terms of manpower, equipment, support services and budget.

6. To develop strategies for installing local preventive maintenance programs.

Process Simulation

1. To provide a series of six realistic situations for participants to integrate the technical and management aspects of their training.

2. To examine how ORDEV engineers assess needs, gather planning data, design, build and provide maintenance for BVS projects.

ORGANIZATION OF THE TRAINING GUIDE

This course is divided into 35 sessions. Each session covers a specific topic. A training session maybe as short as one hour or as long as six. They generally require a half day, depending on the nature of the topic. The times given in the session guidelines do not include meal breaks or short coffee breaks.

The individual session guidelines are grouped according to day and week. The tab for each day includes all the session guidelines for that day as well as any supplementary trainer notes. At the beginning of each week there is a weekly schedule that notes the sequence of each training session for a particular day. Trainer guidelines are written for each training session. These are intended to provide the training staff with some basic instructions on how to conduct the session. Specifically these guidelines include:

- Titles of component and session
- Session objectives
- Outlined instructions for conducting the training activities included in the session
- Times for each step
- List of resources and references to be used in the session.

This guide is intended to help the training staff organize and conduct the technical component of BVS training. It is assumed that the training staff has the technical expertise as well as the training skills necessary for conducting participatory interactive workshops.

BVS Training Course

Participant List

Participant	Governate
Ahmed Ateya Kamel	Sharkia
Ahmed Mohamed Allam	Qalubia
Abdel Ghafar Fhoma	Iswan
Adel Ahmed Morssi	Sohag
Fouad Michael Basili	Giza
Ali Gharib	Gharbia
Mohamed Ali Metwally	Beni Suef
Nabil El Hefni Mohamed	Qena
Shawki Ahmed El-Zerbawi	North Sinai
Hassan Ali Hassan	New Valley
Mohamed Mussa Mohamed Desuki	Kafr El Sheikh
Michael Nassif Michael	Minia
Ali El-Saayeed Mussa	ORDEV
Mohamed Sabri Abu Omra	Menoufia (Alternate)

WEEK NOVEMBER 5 - 9

SCHEDULE

DAY ONE	DAY TWO	DAY THREE	DAY FOUR	DAY FIVE
SESSION 1 ° Introduction to Course	SESSION 3 ° Introduction to Simulation ° Simulation "A": Description of BVS Program	SESSION 5 - 8 ° Phreatic Aquifers ° Causes/Problems of High Groundwater	SESSION 10 ° Hydraulic Review No. 1	SESSION 12 ° Pumps
SESSION 2 ° Overview of Nile River Hydrology	SESSION 4 ° Planning a Water Supply System	SESSION 9 ° Simulation "B": Data Collection Strategy	SESSION 11 ° Control of High Groundwater Levels	SESSION 13 ° Simulation "C": Design Strategy for Water Supply and Sewage Systems

WEEK NOVEMBER 12 - 16

SCHEDULE

DAY SIX	DAY SEVEN	DAY EIGHT	DAY NINE	DAY TEN
SESSION 14 ° Disposal of Excess Ground-water and Wastewater	SESSION 17 ° Maintenance Management Programs	SESSION 19 ° Preventive Maintenance	SESSION 21 ° Simulation "D": Preparation for Local Field Trip SESSION 22 ° Local Field Trip	SESSION 23 ° Preparation of Maintenance Program for Two Pumping Stations
SESSION 15 ° Introduction to Maintenance	SESSION 18 ° Treatment of Wastewater	SESSION 20 ° Design of Sewage Systems		SESSION 24 ° Simulation "E": Operation and Maintenance Planning
SESSION 16 ° Effective Equipment Maintenance				

WEEK NOVEMBER 19 - 23

SCHEDULE

DAY ELEVEN	DAY TWELVE	DAY THIRTEEN	DAY FOURTEEN	DAY FIFTEEN
SESSION 25 ° Water Supply Network Workshop	SESSION 27 ° Water Quality, Testing and Treatment	SESSION 29 ° Maintenance Hardware Needs		
SESSION 26 ° Budgeting for Equipment Maintenance Program	SESSION 28 ° Maintenance Organization	SESSION 30 ° Hydrology Review No. 2	FIELD TRIP	FIELD TRIP
		SESSION 31 ° Preparation for Field Trip		

WEEK NOVEMBER 26 - 30

SCHEDULE

DAY SIXTEEN	DAY SEVENTEEN	DAY EIGHTEEN	DAY NINETEEN	DAY TWENTY
FIELD TRIP	FIELD TRIP	FIELD TRIP	FIELD TRIP	FIELD TRIP

WEEK DECEMBER 3 - 7

SCHEDULE

DAY TWENTY-ONE	DAY TWENTY-TWO	DAY TWENTY-THREE	DAY TWENTY-FOUR	DAY TWENTY-FIVE
SESSION 32 ° Debrief Field Trip SESSION 33 ° Simulation "F": Program and Budget Planning	SESSION 33 ° Continued	SESSION 34 ° Simulation "G": Meeting Between ORDEV Engineers and Senior Gover-norate Managers	SESSION 35 ° Evaluation of Technical Component	GRADUATION CEREMONY

TRAINER OBJECTIVES

DATE: November 5

TIME: 2 hours

COMPONENT: OVERALL

SESSION: 1 -- INTRODUCTION TO COURSE

SESSION OBJECTIVES:

Introduce the second five weeks of training activity.

TECHNICAL COMPONENT: OVERALL

SESSION: 1 -- INTRODUCTION

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
5 min.	1. Re-introduce the course instructors.	° Handout: Names of course instructors
15 min.	2. Return to the needs assessment conducted on October 3. Review the results.	° F. C. Summary of Needs Assessment
45 min.	3. Determine the participants expectations for this portion of the course. ° Individually ° Prioritize in small groups Identify the ones that can be met and the ones that can't. Where revelant relate to needs assessment data.	

3

TECHNICAL COMPONENT: OVERALL

SESSION: 1 -- INTRODUCTION

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
30 min.	4. Present course goals and schedule for the next five weeks. Show on schedule where specific needs and goals will be met.	Handout: Course Goals and Schedule
15 min.	5. Discuss norms for course and introduce the glossary. Namely that we will write English and Arabic versions of commonly used terms, on a flip chart. Assign one person to record on 8½x11 paper for distribution and copying.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 5

TIME: 2 Hours 30 Min

COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

SESSION OBJECTIVES:

1. To continue the warm-up process for the whole course, getting all participants in a common mind as much as possible.

2. To provide or refresh the view of the hydrologic framework of water supply and groundwater flow for each participant's geographical area.

3. To compare similarities and differences among the geographical areas represented.

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Lecturette that includes a basic review of: o White Nile, Blue Nile, Atbara; Main trunk; delta. El Fayoum, El Arish. o Dams and barrages Barrages Aswan low dam Aswan high dam	"Water Resources Management in Egypt," Proceedings of conferences held in Cairo in 1979, 81 and 83, Ministry of Irrigation and CU/MIT, Technological Planning Program, ASRT/Vol/Michigan Nile PROJECT

16

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	o Seasonal stage and discharge before and after the completion of the HAD o High water table problems o Water quality (Turbidity, TDS, BOD) pesticides, industrial, coliforms, schistosomiasis	

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	2. Panel discussion: As each of the four participants preselected to be from different areas, say Kena, Menufia, Ismalia and El Fajoum: Then have each one describe the water systems in his district according to: - Sources - Quality - Treatment Participant's task is to listen to the discussion and gather data that will enable them to compare the similarities and differences among the four different areas being discussed. Participants share their perceptions with panel members.	

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	3. Lecturette/Discussion Groundwater and Hydrogeology Aquifers -- depth and extent Salt water intrusion from Mediterranean Sea The high water table problem	

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	4. Lecturette:	
20 min	Egyptian National Water Plan	
	Egyptian Water Law	

20

TECHNICAL COMPONENT: Water Supply

SESSION: 2. Overview of Nile River Hydrology

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	5. Discussion of existing water law, how it is observed (and in what ways it is infeasible to observe.)	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: NOVEMBER 6

TIME: 2 HOURS 30 MINUTES

COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: 3. Introduction and Preparing a Description of the BVS Program

SESSION OBJECTIVES:

1. To introduce the concept and procedure of a progressive process simulation.

2. To prepare a concise clear description of the BVS program that can be used at the village level.

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: Introduction and Preparing a Description of the BVS Program

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
30 min.	1. Introduce the simulation and explain how it will be done at various points in the course.	
2 hours	2. At this stage of the simulation the participants are assigned one of the following player roles and begin to work on the task outlined below. PLAYERS: 1 chief engineer 3 field engineers METHOD: Work in small groups Teams review each other's outlines	

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: Introduction and Preparing a Description of the BVS Program

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	TASK: Prepare a short presentation on the BVS program for village officials. Outline your presentation on flip chart. Teams move to each flip chart. Review and note what they would: -- add -- delete PRODUCT: Agreed upon description of BVS program.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 6

TIME: 2 Hours 30 Min

COMPONENT: Water Supply

SESSION: 4. Planning a Water Supply System

SESSION OBJECTIVES:

1. To discuss ways to improve the efficiency of the water supply effort.

2. To examine how water supply systems are presently planned, developed, operated and maintained.

TECHNICAL COMPONENT: Water Supply

SESSION: Planning a Water Supply System

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Discussion: Provision of all-new water supply system o Introduce discussion by reviewing results of interviews, at present and planned levels of service in government villages o How are plans made to expand a system? Who sets construction priority, and how? o Are there useful population projections to use?	

TECHNICAL COMPONENT: Water Supply

SESSION: Planning a Water Supply System

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	o How is the service level chosen (i.e. house connections or public taps)? o Is there a staged master plan for orderly sequential development? o Are there water-conservation measures incorporated in the design? (Restricted flow, meters, other) o Design procedure: Who does system layout (routes) and sites pumps, standpipes, pipe sizes, air release values, surge chambers? Who reviews and approves?	

TECHNICAL COMPONENT: Water Supply

SESSION: Planning a Water Supply System

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	2. Lecturette: Planning a Water Supply System o Service level --Public taps advantages, disadvantages when appropriate --House connections advantages, disadvantages when appropriate --restricted flow	

TECHNICAL COMPONENT: Water Supply

SESSION: planning a Water Supply System

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	o Staged master plan -- restricted funds restricted capacity to build limited by numbers of qualified contractors and inspectors, materials -- size of early components to permit easy future expansion	

TECHNICAL COMPONENT: Water Supply

SESSION: Planning a Water Supply System

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	3. Presentation of a relevant case study on the Lexington Kentucky water supply plan	CDM Report on Lexington KY water supply plan
60 min	4. Demonstration of Lotus 1-2-3 and its application to Lexington Kentucky project	IBM PC, Lotus 1-2-3 Software

17. City Water Department billing records indicate the following service history:

Year	Population Served
1915	12,500
1940	54,000
1965	125,000

If in 1982 there is treated-water storage of 400 acre-ft, and water consumption averages 115 gallons/capita/day, how long would storage last if the water treatment plant breaks down?

a. Estimate the 1982 population served by extrapolation of the billing data (Figure 17): 200,000 is the estimate using a French curve.

b. This served population x 115 gallons capita/day is 23 million gallons/day.

c. $400 \text{ acre-ft} \times \left(\frac{43{,}560 \text{ ft}^2}{\text{acre}}\right) \times \left(\frac{7.48 \text{ gall}}{\text{ft}^3}\right) = 130 \text{ million gallons}$

d. $130 \text{ million gallons} \times \left(\frac{1 \text{ day}}{23 \text{ million gallons}}\right) = \underline{5.7 \text{ days}}$

18. The cross-section of a channel, together with its adjacent floodplain, is shown in Figure 18. The average longitudinal slope of the channel and its valley is S = 0.00031. During a flood in which the water level rises to El. 910 ft, what is the total discharge and average velocity?

Apply Manning's formula separately to each region of flow: overbank (cornfield), main channel, and overbank (brush). The formula in foot - pound - second system units is:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

No side-slope information is given, but in cases where the flow width is much greater than the depth, there is little error introduced by neglecting the channel sides. Furthermore, the hydraulic radius, R, is approximately equal to the flow depth for wide, shallow channels.

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 7

TIME: 30 min

COMPONENT: Groundwater/Wastewater

SESSION: 5-8. Introduction

SESSION OBJECTIVES:

To review the definition of groundwater and describe the two basic types of groundwater in the course.

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Introduction

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 Min for Items 1-5	1. Definition of groundwater: Present a review of hydrologic cycle. Focus on formation of groundwater within the cycle.	Handout: GW-1-A Sketch of hydrologic cycle.

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. Describe the three stages of the groundwater cycle: o infiltration o storage o output (outflow)	Sketch of hydrologic cycle.

TECHNICAL COMPONENT: G/W

SESSION:

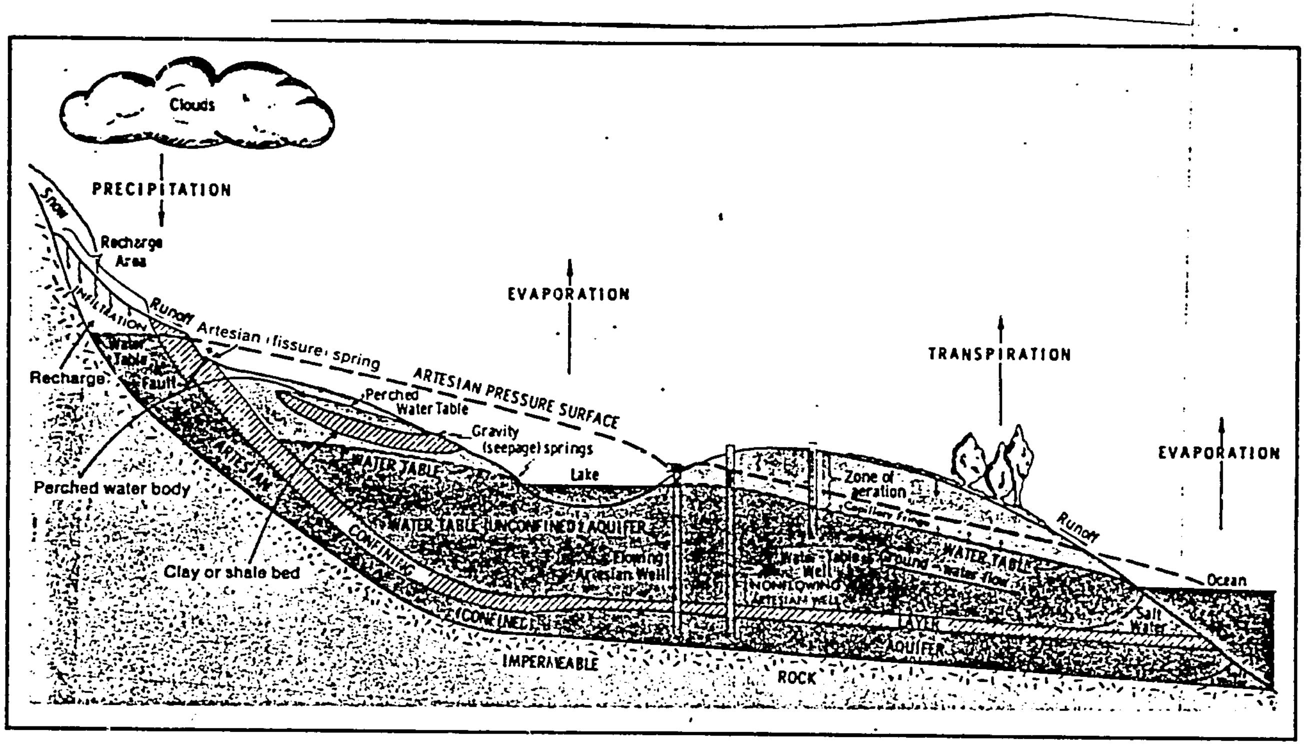
TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Describe inflitration/recharge	Sketch of hydrologic cycle
	4. Describe outflow (springs, underwater, discharge others)	

TECHNICAL COMPONENT: G/W

SESSION:

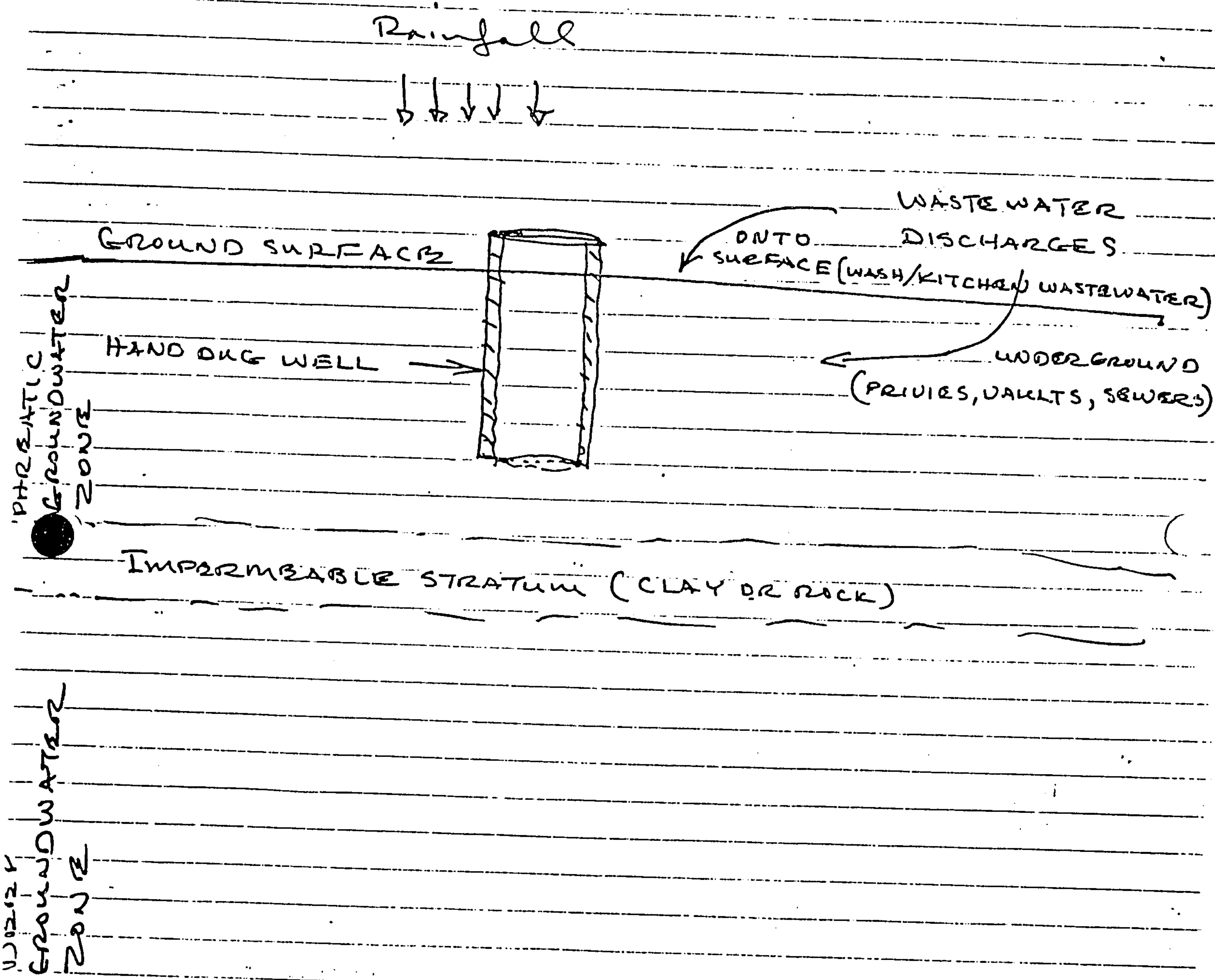
TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	5. Focus on groundwater storage in aquifers -- phreatic (shallow) and deep aquifers.	Prepare large sketch on flip chart.

36



The Hydrologic Cycle

LARGE SKETCH OF GROUND WATER



BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 7

TIME: 30 Min

COMPONENT: Groundwater/Wastewater

SESSION: 5-8. Phreatic Aquifers

SESSION OBJECTIVES:

To describe the occurrence and characteristics of phreatic aquifers.

39

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Phreatic Aquifers

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
Note: 30 Min for 1-4	1. Define phreatic aquifers	Use flip chart See sketch from session 1.
	2. Describe occurrence of phreatic aquifers	

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Phreatic Aquifers

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Describe characteristics of phreatic groundwater	
	4. Discussion	

5

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 7

TIME: 1 Hr. 35 Min.

COMPONENT: Groundwater/Wastewater

SESSION: 5-8. High Levels of Phreatic Groundwater

SESSION OBJECTIVES:

To describe and discuss the causes of high phreatic groundwater levels.

To draw (sketch in detail) how the 4 main causes of high phreatic groundwater actually operate.

52

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
5 min	1. Ask the group: "How many of you have high levels of groundwater in your area?" After the show of hands, ask them the name the areas (districts) with the problem of high groundwater levels. Record these areas down one side of a flip chart page. (Allow room for later writing in the causes of this problem next to each area.) When the list is completed, make appropriate comments such as: "It seems to affect many parts of your country..."	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
15 min.	2. Go back to the list and ask them to think about the causes of this problem. After a few minutes, ask them what they think the causes are and record these next to the various geographic areas which have been already listed. If the list does not contain the following causes, challenge them to come up with more:	Prepare large sketch on flip chart. HANDOUTS: GW-3-A,B,C,D,E,F
20 min.	o Land surface characteristics (focus on Nile delta) o Increased use of water for irrigation o Seepage from river, canals and drains o Increased wastewater from potable water supplies o Rainfall	Prepare sketch on flip chart Show slides Hydrologic cycle handout

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	3. Divide them into four groups and ask them to: o Discuss how each of the four main causes creates high levels of groundwater. o Select one of the causes and sketch on flip chart how it operates (During this task, move around the room to be sure that the four main causes are being sketched -- one per group).	

TECHNICAL COMPONENT: G/W

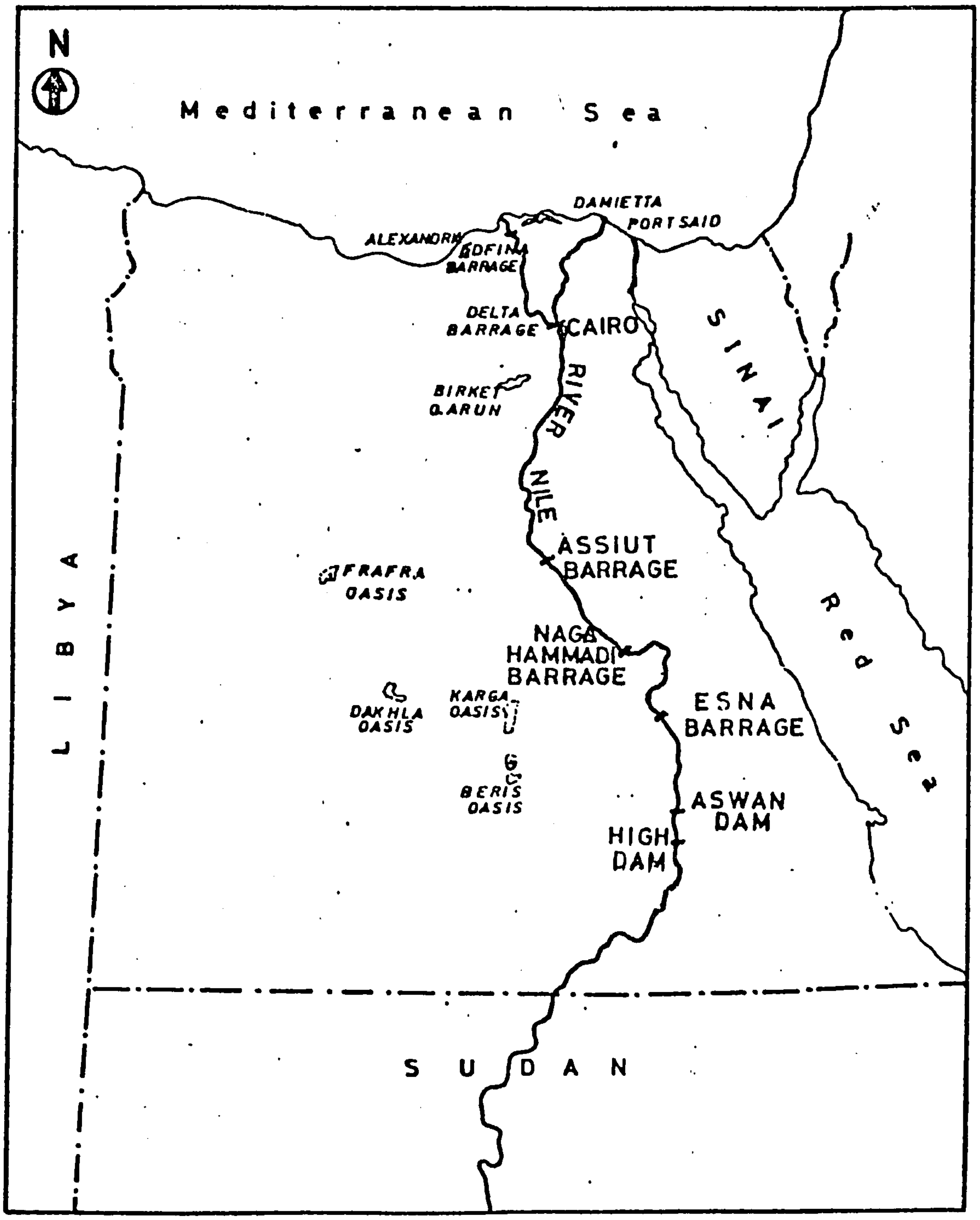
SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min.	4. Each of the groups report out using their sketches as a visual aid. Since everyone has discussed how the causes function there should be some good questions from the participants about each of the presentations.	

TECHNICAL COMPONENT: G/W

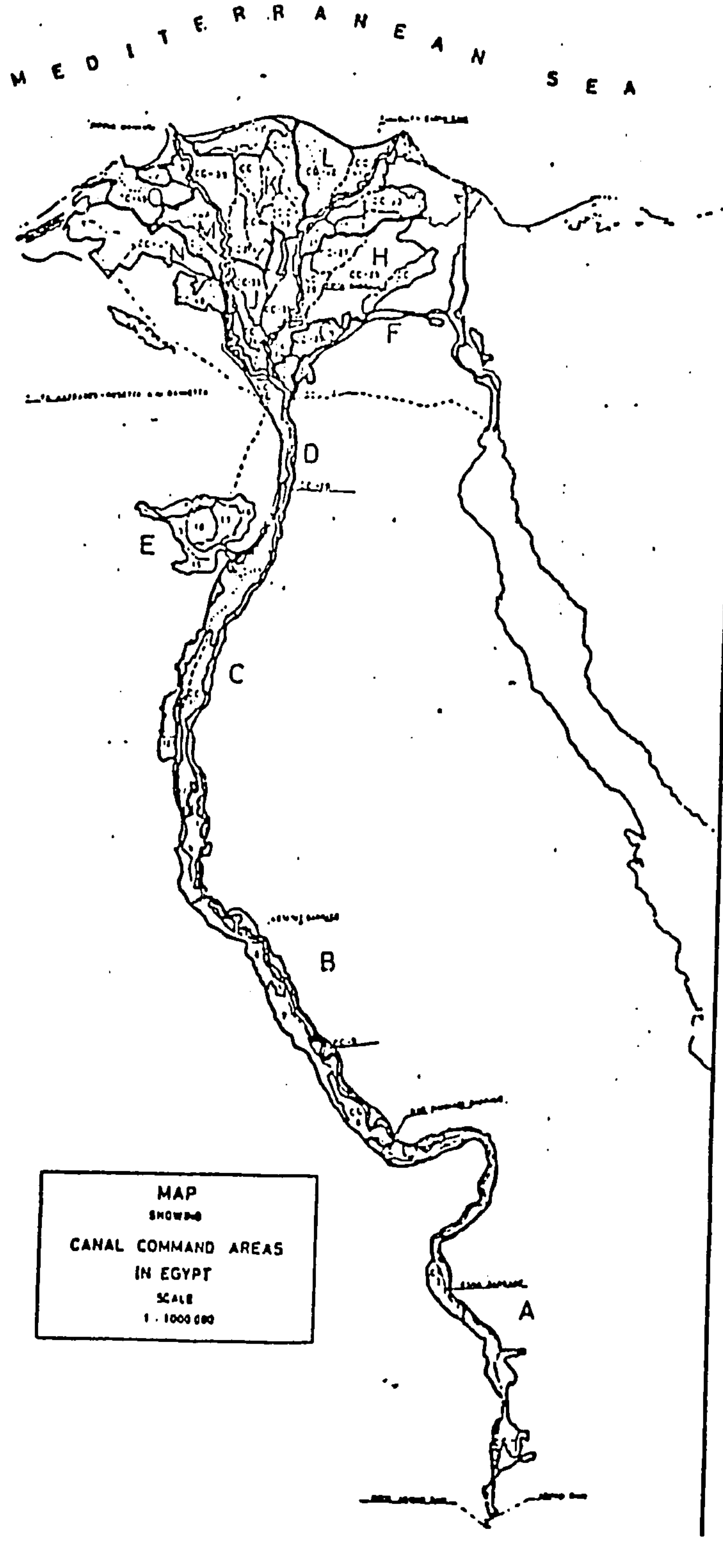
SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
10 min	5. Ask the participants what they learned about causes that helped them understand the reasons behind why they might have high groundwater in their regions. Record their responses on the flip charts.	

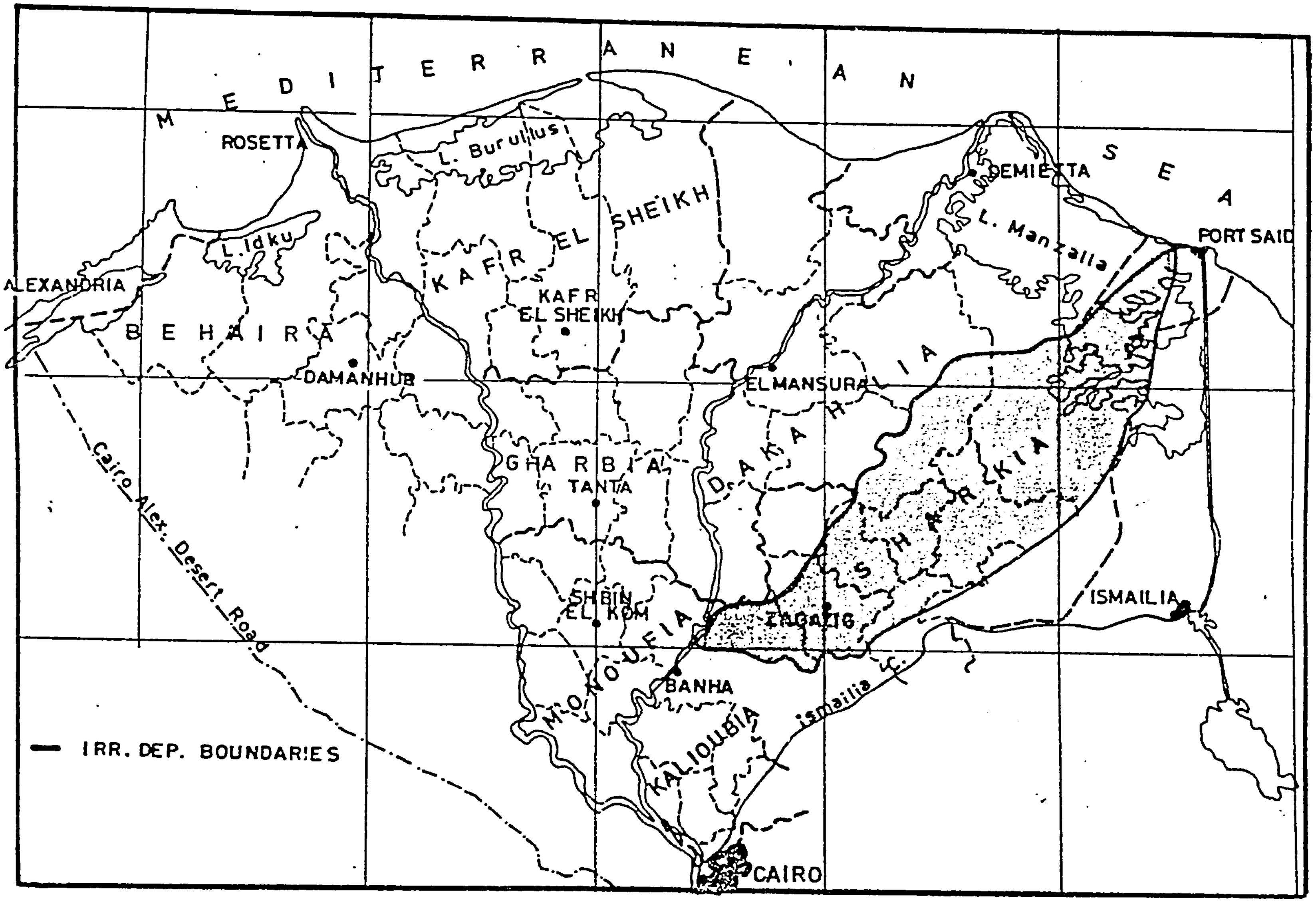


EGYPT'S WATER RESOURCES

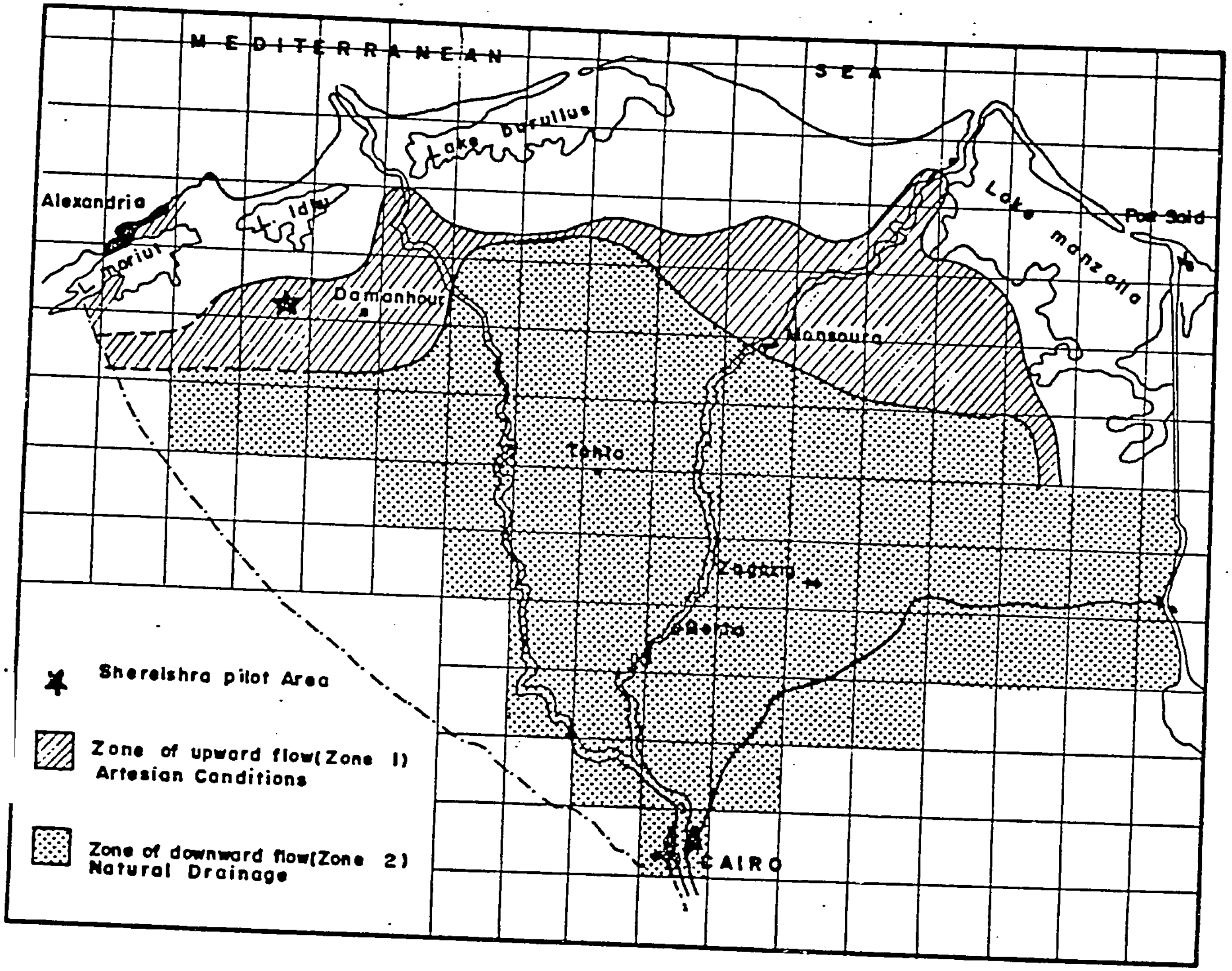
FIGURE 1


MEDITERRANEAN SEA
L
K
M
N
H
F
D
E
C
B
A
MAP
SHOWING
CANAL COMMAND AREAS
IN EGYPT
SCALE
1 : 1000 000

HANDOUT GW-3-C

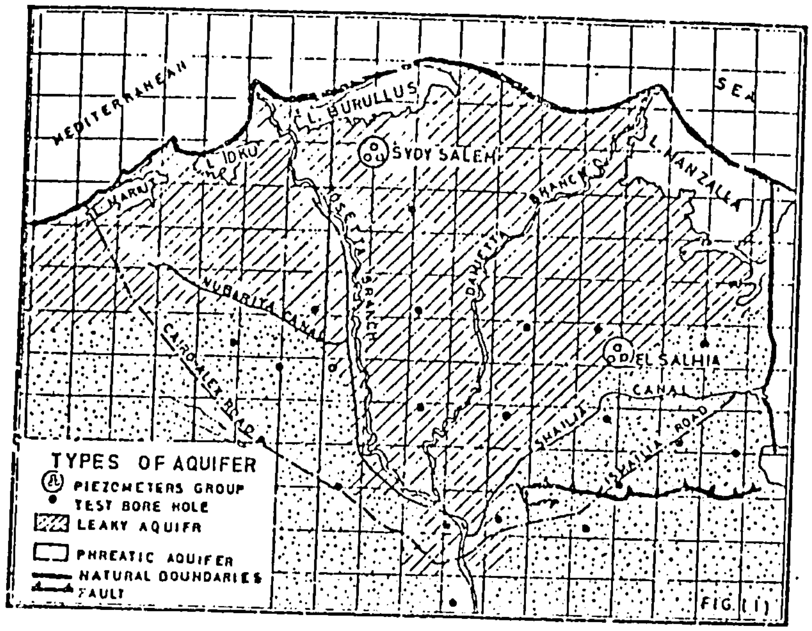


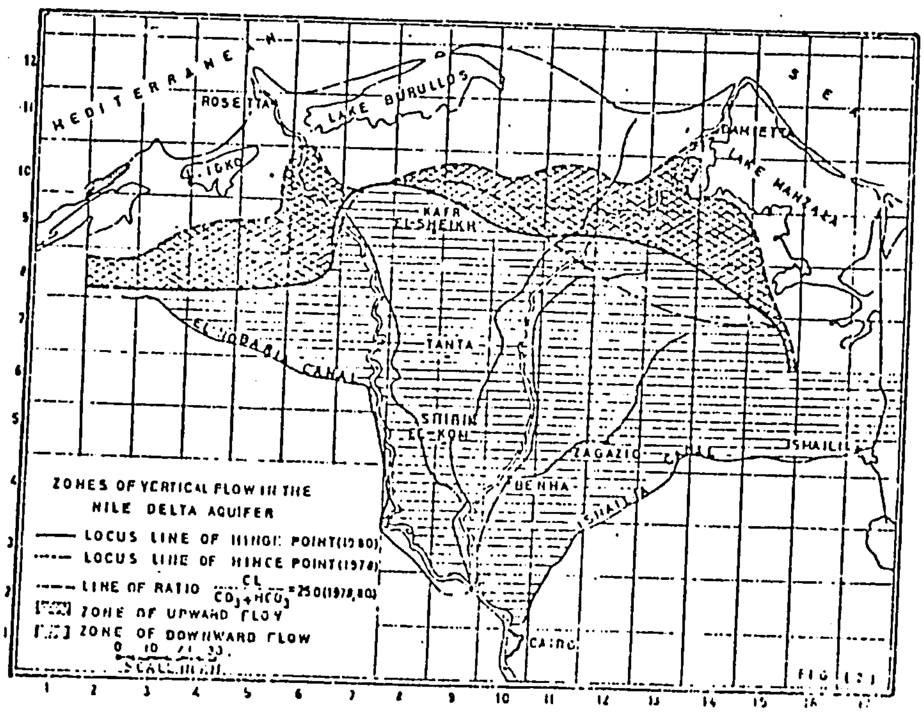
ADMINSTRATIVE GOVERNORATES IN THE NILE DELTA REGION



Fig(1) ARTESIAN AREAS OF THE NILE DELTA.[3].

HANDOUT GW-3-E





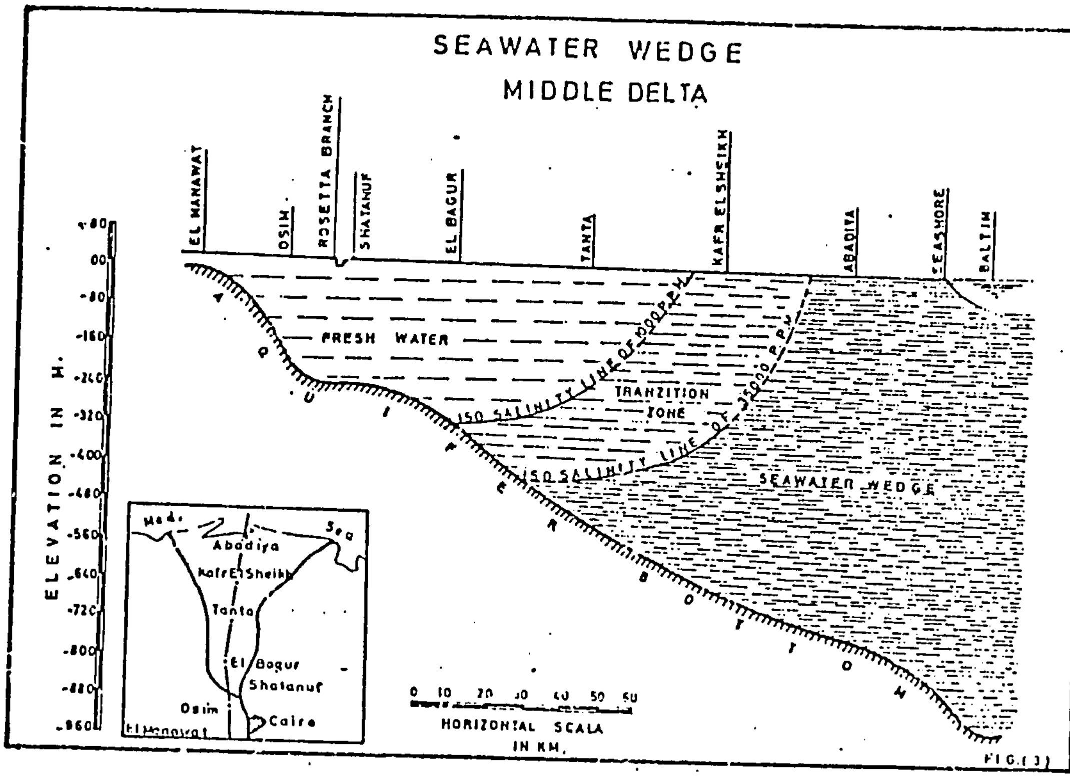
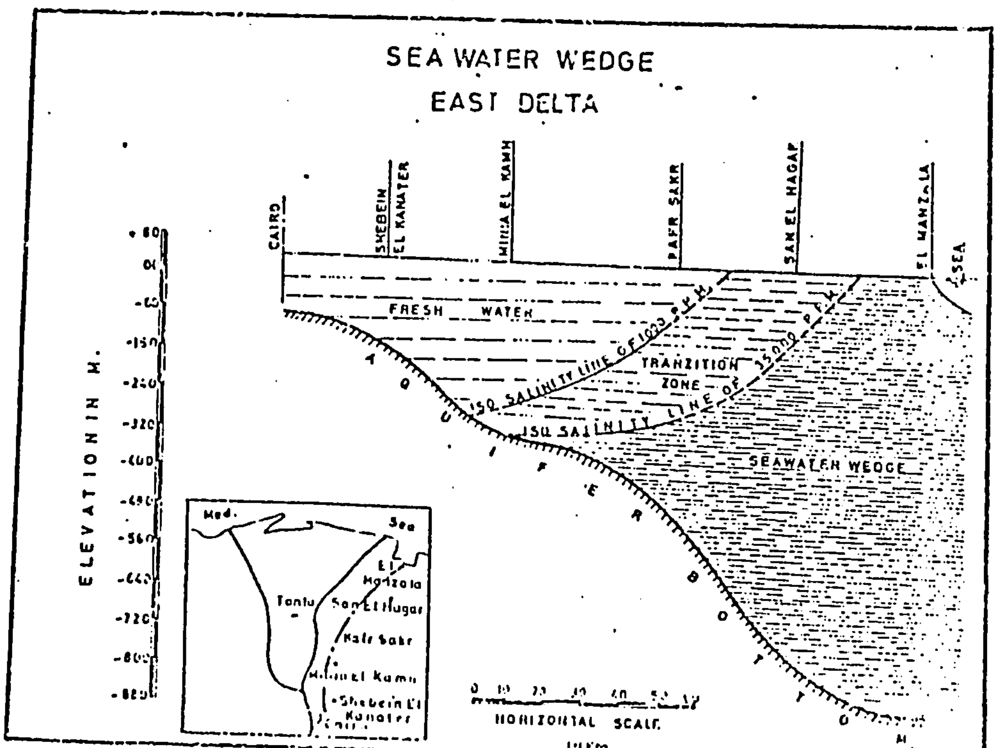

SEAWATER WEDGE
MIDDLE DELTA
EL MANAWAT
OSIM
ROSETTA BRANCH
SHATANUF
EL BAGUR
TANTA
KAFR ELSHEIKH
ABADIYA
SEASHORE
BALTIM
FRESH WATER
TRANZITION
ZONE
SEAWATER WEDGE
ELEVATION IN M.
+80
00
-80
-160
-240
-320
-400
-480
-560
-640
-720
-800
-880
-960
Med.
Sea
Abadiya
Kafr El Sheikh
Tanta
El Bagur
Shatanuf
Osim
Cairo
0 10 20 30 40 50 50
HORIZONTAL SCALA
IN KM.

FIG.(3)


SEA WATER WEDGE
EAST DELTA
CAIRO
SHEBEIN EL KANATER
MINIA EL KAMH
KAFR SAKR
SAN EL HAGAR
EL MANZALA
SEA
FRESH WATER
TRANZITION
ZONE
SEAWATER WEDGE
ELEVATION IN M.
+80
00
-150
-240
-320
-400
-560
-640
-720
-800
Med.
Sea
Tanta
HORIZONTAL SCALE

53

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 7

TIME: 1 Hour/30 Min.

COMPONENT: Groundwater/Wastewater

SESSION: 5-8. Problems caused by high levels of phreatic groundwater.

SESSION OBJECTIVES:

- To identify and describe types of problems caused by high groundwater levels and relate these to the causes described in the previous session.

- To examine how these problems impact village life.

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Problems caused by high levels of phreatic groundwater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	1. Describe major problems caused by high groundwater. Focus on problems in the Nile delta. Make linkage to previous session Recall the four major causes of high groundwater. Ask participants to call out some of the problems in their particular areas of operation. Quickly record this on flip chart as they say them. Show slides of typical problems. Nile Delta for example: o Pools of sewage and wastewaters o Mudholes o Overflowing sewage vaults (cesspits) o Moisture and water in homes o Collapse of mud-brick homes	Use color slides from photos photos in WASH Field Report No. 133

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min.	2. Present the following small group task that encourages participants to look at the relationship between causes and problems of high groundwater and how these impact village people. Divide the participants into three or four small work groups and assign them a portion of the previously written list of problems. Prepare the following outline an flip chart and ask each work group to complete one like it.	

GROUP ______________________

HIGH GROUND-WATER PROBLEM	CAUSES	EFFECT ON VILLAGE PEOPLE

Tell each group to be prepared to present their completed charts to the total group.

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20-25 min.	3. Reports to total group. Each group presents its chart. Note similarities and ask clarifying questions. Encourage participants to do likewise.	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	4. Ask them to think back on the reports they just heard and then write down what new insights or learnings they have about the effects of high groundwater problems.	
15 min		
	When they finish, ask them to share some of their learnings and record them on the flip chart.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 7

TIME: 2 hrs 15 min

COMPONENT: Process Simulation: ORDEV Engineers

SESSION: 9. Data Collection Strategy

SESSION OBJECTIVES:

1. To develop a practical strategy for gathering data in the field prior to designing a system.

2. To reach agreement on the best approach to use for gathering data.

TECHNICAL COMPONENT: Process Simulation: ORDEV Engineers

SESSION: Data Collection Strategy

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	1. Introduce this stage of the simulation by explaining that the following sequence of events related to BVS Project Identification have occurred since the group last met. ° ORDEV engineers have briefed village officials on BVS program ° The village officials have met with villagers to discuss village needs and priorities. The villagers decided on a project. ° The village officials have presented their project decisions to the chief of ORDEV. The merits were discussed and an agreement was reached.	

TECHNICAL COMPONENT: Process Simulation

SESSION: Data Collection Strategy

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
2 hours	2. At this stage of the simulation, the participants are assigned one of the following player roles and begin to work on the task outlined below: SETTING: ORDEV Offices PLAYERS: 1 chief engineer 3 field engineers METHOD: Work in small groups Share on flip chart in large group. Instructor reviews with participants within the group. TASK: Prepare a practical strategy for gathering basic data to design a water supply or sewerage system.	

61

TECHNICAL COMPONENT: Process Simulation

SESSION: Data Collection STrategy

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	TASK (continued) Your strategy should include: o list of information you need o sources of needed information o resources required to get information: -- staff -- equipment -- time o summarize or outline your strategy on flip chart PRODUCT: agreed upon strategy for data collection	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 8

TIME: 3 Hours

COMPONENT: Water Supply

SESSION: 10. Hydraulic Review I

SESSION OBJECTIVES:

To refresh one's knowledge of basic pipeline hydraulics, for what follows in this course and for general use.

63

TECHNICAL COMPONENT: Water Supply

SESSION: Hydraulic Review I

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	The following topics will be covered in a basic lecture/discussion review of pipeline hydraulics: 1. Hydrostatics 2. Equations of Continuity, Momentum and Energy 3. Energy losses due to form and friction 4. Hydraulic profile 5. System curve 6. Network analysis: Hardy Cross method	Hydraulics Review Notes

HYDRAULICS

This section begins with a review of basic concepts and formulas. Examples are worked and discussed. The section closes with a glossary of commonly used terms and symbols.

Basic Concepts and Formulas

1. Hydrostatics

The hydrostatic pressure difference, $P_1 - P_2$, between two elevations Z_1 and Z_2, is proportional to the unit weight of fluid and to the elevation difference:

$$P_1 - P_2 = w\ (Z_2 - Z_1) = \rho g\ (Z_2 - Z_1) \qquad (1\text{-}1)$$

In Figure 1-1, at a depth h beneath the water surface in the tank, the gauge pressure is just wh, where w is the unit weight of water, 62.4 lb/cu ft. or 1000 kg/cu m. The absolute pressure is gauge pressure plus atmospheric pressure.

At sea level, atmospheric pressure is about 14.7 psi, or 2116.8 psf; in terms of head of water, 34 ft or 10.4m; in terms of head of mercury, 30 inches or about 760 mm.

Again in Figure 1-1, the pressure at (2) is $P_1 + wh_2$, or $w\ (h_1+h_2)$. Since (2) and (3) are at the same elevation, $P_2 = P_3$. P_3 also equals Patm+ wsh_3m where s is the specific gravity of mercury, 13.6.

Knowing s, h_2 and h_3, one may deduce h_1, the depth of water in the tank. Conversely, knowing h_1, h_2, and h_3 one may deduce s.

The hydrostatic force on a plane area is equal to the hydrostatic pressure that exists at the centroid of the area, multiplied by the area; and the force acts in a direction normal to the plane. In Figure 1-1, the force on the bottom of the bank is (Patm + wy)A_i, and acts downward. The force on the left wall of the tank is (Patm + wy/2)A_{ii} and acts horizontally to the left.

See Examples 1 and 13.

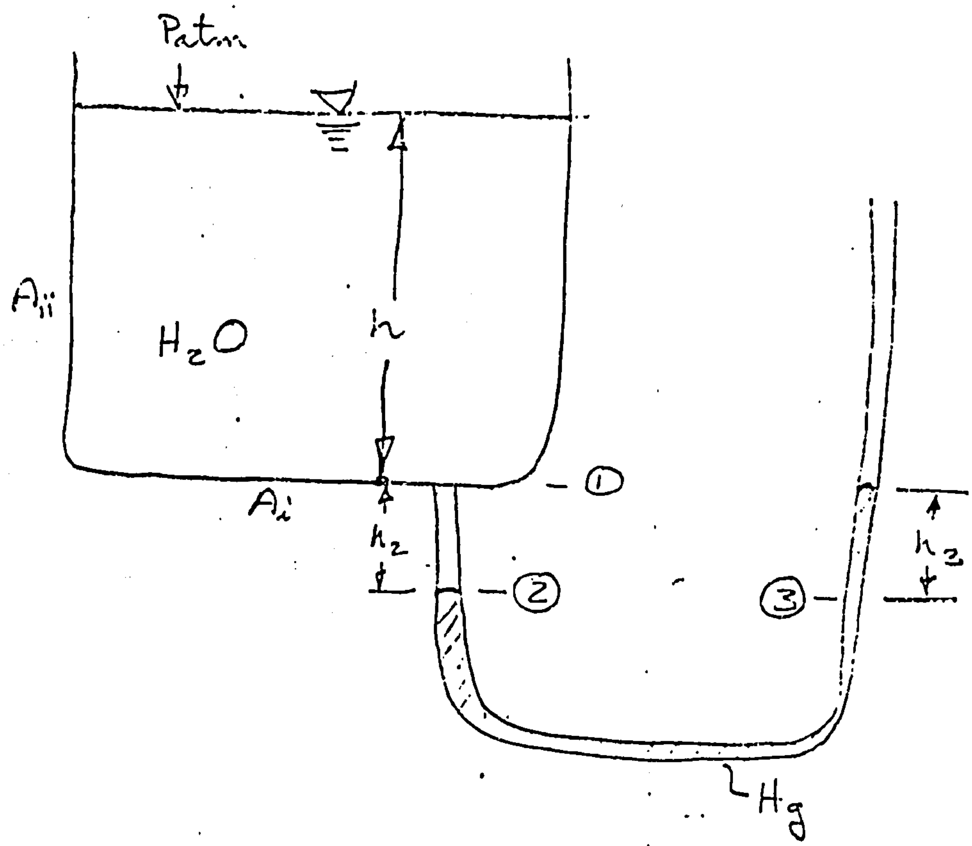


FIGURE 1-1.

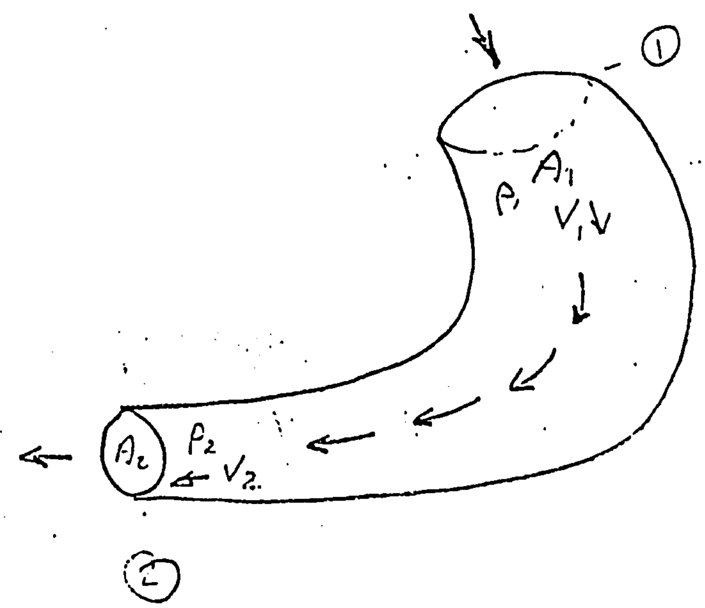


FIGURE 2-1

2. Continuity.

Unless there is a storage accumulation or drawdown in a conduit, the mass flow rate through a conduit is constant from point to point along the conduit.

In Figure 2-1, the mass flow rate at Station 1, is $\rho_1 A_1 V_1$, the product of density, cross-sectional area, and velocity there. At Station 2 it is $\rho_2 A_2 V_2$.

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

For many hydraulics problems where fluid compressibility is negligible, ρ_1 and ρ_2 may be considered equal, and

$$A_1 V_1 = A_2 V_2$$

Example: Hydraulic jump in a flow of water in a channel of width, b_1, b_2. (See Figure 3-1). The density, ρ, may be considered constant, so

$$A_1 V_1 = A_2 V_2$$

Now $A_1 = b_1 y_1$ and $A_2 = b_2 y_2$, so.

$$b_1 y_1 V_1 = b_2 y_2 V_2$$

If channel width is constant, $b_1 = b_2$, and $y_1 V_1 = y_2 V_2$.

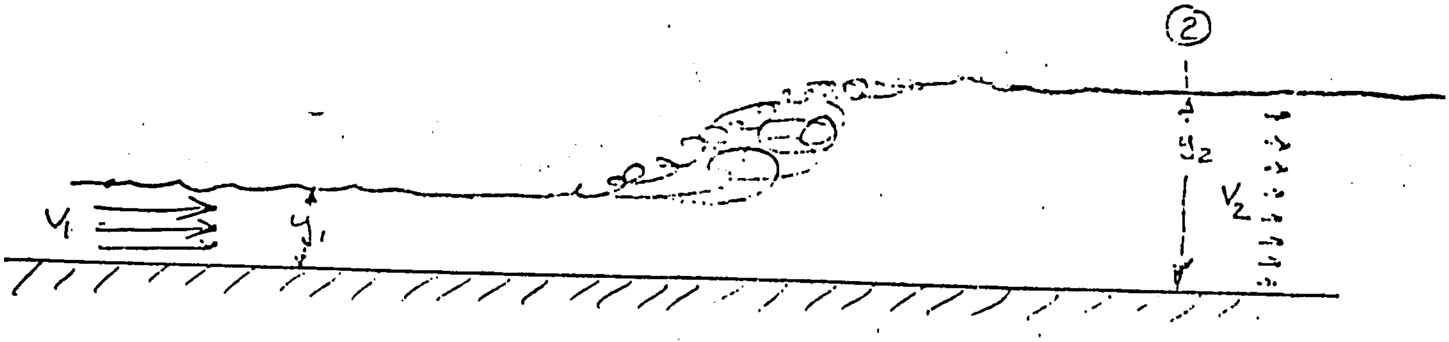


FIGURE 3-1

3. Momentum

(Basically, Force = mass x acceleration, Newton's Second Law of Motion).

Force, momentum, distance, velocity, and acceleration, are vector quantities, in that one must specify their direction as well as their magnitude. (Temperature, pressure, and energy are scalar quantities, with magnitude only. Pressure (a scalar) x area (a vector whose "direction" is perpendicular to the plane of the area) equals a force (a vector).

Force equals mass x acceleration. Acceleration includes a time rate of change in velocity in unsteady flow at one station, and a change in velocity in a stead flow as fluid moves from Station (1) to Station (2).

The basic momentum equations for steady flow in three space dimensions x, y, and Z are:

$$\Sigma Fx = \rho Q\ (V_{x2} - V_{x1})$$

$$\Sigma Fy = \rho Q\ (V_{y2} - V_{y1})$$

$$\Sigma Fz = \rho Q\ (V_{z2} - V_{z1})$$

The ΣF_x are the hydrostatic and boundary forces acting on the fluid that are equal and opposite to the change in momentum in the x direction experienced by the fluid. The ΣF_y and ΣF_z are similar forces in the y and z directions, respectively.

These equations are applied as follows:

Example: Hydraulic jump in a rectangular channel of constant width, with zero slope, and negligible friction (see Figure 3-1).

There are no bends, so we only need to consider forces acting upstream and downstream (on the x-axis).

At (1), the force on the fluid body is the hydrostatic pressure integrated over the flow depth:

$$F_1 = b \int_0^{y_1} P_1 (y)\, dy, \qquad P_1 = \rho g \,(y_1 - y)$$

$$F = \rho g b \left[y_1\, y - y^2/2 \right]_0^{y_1} = \rho g b y_1{}^2/2$$

The force acts to the right, inward on the body; at (2), the force is $F_2 = \rho g b y_2^2/2$. The force acts to the left, inward on the body.

The rate of change of momentum is

$$F_x = F_1 - F_2 = \rho Q\,(V_2 - V_1)$$

$$\rho g b(y_1{}^2/2 - y_2{}^2/2) = \rho Q\,(V_2 - V_1)$$

(If one is given Q, which equals V_1 by 1 and V_2 by 2; and if one is given b and, say, y_1, one can now solve for V_1, V_2 and y^2.)

See Examples 2 and 3.

4. Energy

The energy equation, or Bernoulli equation, is a means of keeping track of the energy budget in a flow system: potential energy, kinetic energy, energy lost in gradual or sudden dissipation, energy provided by a pump, energy extracted by a turbine.

In one-dimensional hydraulics analysis, energy is measured in terms of pressure head, units of length (feet, metres). ("Head" multiplied by unit weight, ρg, is "pressure", which is "energy per unit volume". Recall that the potential energy of a body of mass m situated at a height h above a reference datum is mgh, and that its kinetic energy is $1/2\ mv^2$, and that its total energy is the sum of the two: $m\ (gh + 1/2\ v^2)$. Divide by the volume of the body to get $\rho\ (gh + 1/2\ v^2)$, where $\rho = m/\text{volume}$. Divide by ρg to express total energy in terms of head: $h + v^2/_{2g}$. This is often called the <u>specific energy</u>.

The Bernoulli equation may be written as:

$$Z_1 + y_1 + \frac{v_1{}^2}{2g} = Z_2 + y_2 + \frac{v_2{}^2}{2g} + h_f + h_t - h_p \qquad (4\text{-}1)$$

The left-hand side, $Z_1 + y_1 + v_1{}^2/2g$, is the total energy head at a station (1), upstream. The first term, Z_1, is the elevation of the floor of the channel or the invert of the pipe. The second term, y_1, is the piezometric elevation. Together, $Z_1 + y_1$, indicate the potential energy at (1). The velocity head, $v_1\ ^2/_{2g}$, denotes the kinetic energy.

The piezometric elevation, y, in an open channel is merely the water depth. In a closed conduit flowing full, it is the "artesian pressure head", the height to which fluid would rise in a piezometer tube, a test bore piercing the crown of the pipe (Figure 4a).

The right-hand side of Equation 4-1 includes the total head at a second station, $Z_2 + y_2 + v_2{}^2/_{2g}$, and all terms responsible for change in total head between stations (1) and (2): friction and form loss, h_f; turbine head, ht; and pumping head, h_p.

In Figure 4-b, consider a Pitot tube, used for measuring current speed. A Pitot tube actually contains two tubes, one bent so that its end aperture faces directly into the oncoming flow (A), the other's opening facing across the flow (B). Write the Bernoulli equation, neglecting any friction losses:

$$Z_A + Y_A + \frac{VA^2}{2g} = Z_B + Y_B + \frac{VB^2}{2g}$$

The elevations Z_A and Z_B are the same. The velocity of flow past B, B, is the velocity of the flow being measured. However, (A) is designed to be at a stagnation point, where the velocity directly ahead of the tube is brought to a stop, so that A = 0. Thus

$$Y_A = Y_B + V_B^2/2g$$

Tube A measures total head and is called a total head tube. Tube B is another example of a piezometer tube. By measuring the difference in water levels in the two tubes, $Y_A - Y_B$, we can deduce the flow velocity, B.

Study each part of Figure 4a, and see Examples 3 and 13.

A. Hydraulic profile is the hydraulic grade line computed throughout a flow system. An example is the HGL shown in Figure 4a. If the flow rate is known, the rate of energy loss due to form is calculated for each bend, junction, or change in pipe size, and the rate of energy loss due to friction is calculated for each length of pipe. For the known flow rate, the energy grade line is calculated for each point in the system, beginning and/or ending with a reservoir. The hydraulic grade line is calculated for each point from knowledge of the energy grade line and the average flow velocity.

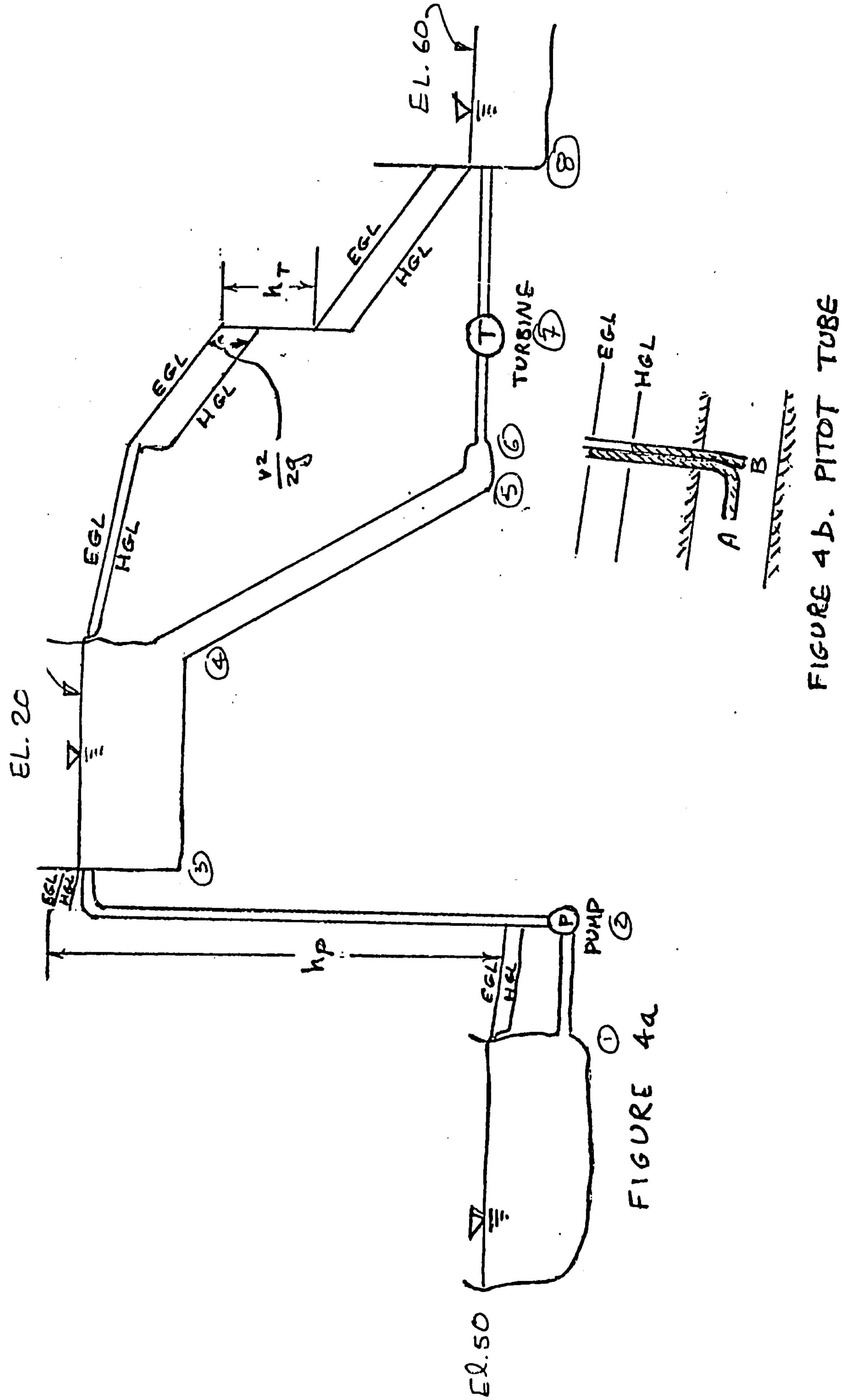


FIGURE 4a

FIGURE 4b. PITOT TUBE

5. Pressure Losses, due to Form and to Friction

As fluid moves through a channel or conduit, it dissipates kinetic energy, and loses pressure, or "head".

See the definition for "total head" in Section 4. Total head represents the sum of the potential and kinetic mechanical energy in the flow. Head is lost when kinetic energy is dissipated, due to wall friction, and due to inefficient flow patterns at bends.

Kinetic energy is proportional to V^2 and Q^2 (remember, K.E. = $1/2\ mV^2$ from elementary mechanics). Headloss is also proportional to V^2 and Q^2 via a "loss factor" or a"friction factor". These are dependent on the Reynolds number, $\mathbb{R}$. For sufficiently large flows, as found in medium to large conduits, the loss factors are independent of $\mathbb{R}$ and hence of velocity:

$$h = K\frac{V^2}{2g} \qquad (5\text{-}1)$$

in which K depends on conduit geometry, but not on V. Another example is the Manning friction formula:

$$V^2 = \frac{1}{n^2} R^{4/3} \frac{h}{L} \qquad (5\text{-}2)$$

in which R is the hydraulic radius (compare Equation 5-2 with Equations 5-5 and 5-6).

For very small Reynolds number, such as for flow through sand or clay aquifer or through capillary tubes, the friction factor is inversely proportional to $\mathbb{R}$, hence V, so that

h is proportional to fV^2, which

is proportional to $(\frac{1}{V})\ V^2$; so that

h is proportional to V.

Examples of equations for this condition are the Darcy law for groundwater flow and the Kozeny and Fair Hatch equations for flow through porous filter media.

Friction Loss Formulas

The Hazen-Williams formula is an attempt to describe the headloss relationship for intermediate values of IR:

$$h = 10.6\ L\ \left(\frac{Q}{CD^{2.65}}\right)^{1.85} \qquad (5\text{-}3)$$

in which loss h, diameter D, and length L are in feet, and Q is in mgd. The friction factor C is about 130 for smooth pipe, 100 for average pipe, and about 80 for rough-walled pipe.

This formula, with the exponent of 1.85 less than 2 and more than 1, is intended for small-diameter pipe systems. It is not theoretically elegant, but has been and continues to be used widely, rendering adequate results when used as intended. See Example 14.

The Darcy-Weisbach formula is the most elegant and general of the friction formulas, in that it covers the full range of $\mathbb{R}$, and may be used with any liquid or gas:

$$S = \frac{h}{L} = \frac{f}{D}\frac{V^2}{2g} \qquad (5\text{-}4)$$

In this formula the friction slope, $S = h/L$, is simply related to the velocity head and the pipe diameter by the coefficient f. This coefficient f is a function of flow Reynolds number, $\mathbb{R} = VD/\nu$, and the relative roughness of the pipe or channel wall, ε/D, as shown on the friction factor diagram in Figure 5-1.

The figure shows that for small $\mathbb{R}$, $f = 64/\mathbb{R}$, so that $s = h/L = 64\ \nu V/2gD^2$, i.e., S and h are proportional to V, as in Darcy's Law for groundwater flow.

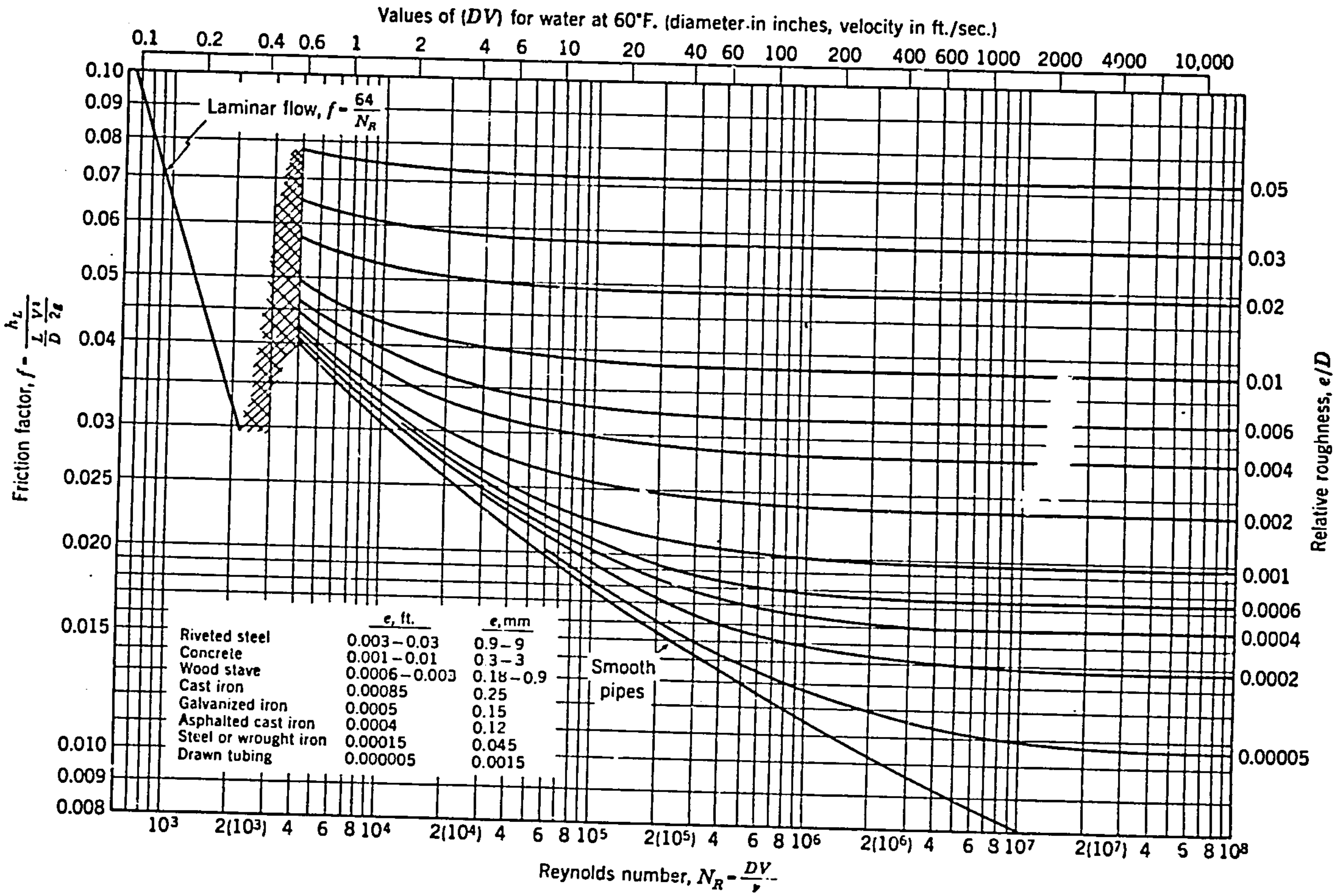


FIGURE 5-1

Moody friction factor diagram for estimating F in pipe. From Linsley and Frazini, Water Resources Engineering, 3rd Edition, McGraw-Hill, 1979.

For large R, the figure shows horizontal lines of constant f, indicating that f is independent of R, and depends only on k/D. This represents completely turbulent flow very often encountered in practical large-pipe or open-channel flow problems. The roughness dimension, k, is the typical height of roughness elements or "bumps" on the pipe wall. Ranges of values of k characteristic of several pipewall materials are given in the inset table of Figure 5-1.

For intermediate values of R, f is a function of both R and k/D. The functional relationship in this zone has been expressed in terms of empirical formulas, such as those by Colebrook and White; for review purposes it is adequate to simply drive the relationship from the curves on Figure 5-1. See Example 8.

The Manning formula, applicable to large - R flows in which friction is independent of IR, is convenient and widely used for many civil engineering flow applications. In SI units:

$$Q = \frac{1}{n} AR^{2/3} S^{1/2} \qquad (5\text{-}5)$$

in which:

Q, m^3/sec, is the discharge

A, m^2 is the cross-sectional area

R,m, is the hydraulic radius

S (dimensionless) is the friction slope

In the foot-lb-second system, in which Q is in cfs, A is in ft^2, and R is in feet:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2} \qquad (5\text{-}6)$$

The friction factor, n, increases with increasing wall roughness. Suggested values are given in Table 5-1. See Examples 4 and 5.

TABLE 5-1

VALUES OF n FOR USE IN MANNING OR KUTTER FORMULA *

0.009 and 0.010	Very smooth and true surfaces, without projections. Clean new glass, pyralin, or brass, with straight alignment.
0.011 and 0.012	Smoothest clean wood, metal, or concrete surfaces, without projections, and with straight alignment.
0.013	Smooth wood, metal, or concrete surfaces without projections, free from algae or insect growth, and with reasonably straight alignment.
0.014	Good wood, metal, or concrete surfaces with very small projections, with some curvature, with slight insect or algae growth, or with slight gravel deposition. Shot concrete surfaced with troweled mortar.
0.015	Wood with algae and moss growth, concrete with smooth sides but roughly troweled or shot bottom, metal with shallow projections. Same with smoother surface but excessive curvature.
0.016	Metal flumes with large projections into the section. Wood or concrete with heavy algae or moss growth.
0.017	Shot concrete, not troweled, but fairly uniform.
0.018 to 0.025	Metal flumes with large projections into the section and excessive curvature, growths, or accumulated debris.
0.016 to 0.017	Smoothest natural earth channels, free from growths, with straight alignment.
0.020	Smooth natural earth, free from growths, little curvature Very large canals in good condition.
0.022	Average, well constructed, moderate-sized earth canal in good condition.
0.025	Very small earth canals or ditches in good condition, or larger canals with some growth on banks or scattered cobbles in bed.
0.030	Canals with considerable aquatic growth. Rock cuts, based on average actual section. Natural streams with good alignment, fairly constant section. Large floodway channels, well maintained.
0.035	Canals half choked with moss growth. Cleared but not continuously maintained floodways.
0.040 to 0.050	Mountain streams in clean loose cobbles. Rivers with variable section and some vegetation growing in banks. Canals with very heavy aquatic growths.
0.050 to 0.150	Natural streams of varying roughness and alignment. The highest values for extremely bad alignment, deep pools, and vegetation, or for floodways with heavy stand of timber and underbrush.

*From Rouse, Engineering Hydraulics, Wiley, 1950.

Form Loss

"Form loss" occurs whenever there is a separation of flow at a boundary, creating a zone of eddying and turbulent dissipation of energy. Such flow separation occurs at nearly any sudden change in channel wall direction, as at sharp bends or sudden contractions or expansions. The form headloss proportionality constant K in Equation 5-1 is a function of local pipe geometry and Reynolds number; at sufficiently high Reynolds numbers, the case for many practical applications, K is a function of geometry only. Values of K for use in Equation 5-1 are listed in Table 5-2.

Example 7 is an application in which the total loss of energy head in the course of flow from one reservoir to another is computed by determining the K-value and v for each occasion of form loss, summing all $K\ v^2/2g$, and adding friction loss.

TABLE 5-2

VALUES OF HEADLOSS COEFFICIENT FOR SOME FITTINGS, BENDS, AND SECTION CHANGES

Item		K
Square elbow, single-mitre bend		1.0
Sudden enlargement (use upstream velocity for V)	$d_1/d_2 = 3/4$	0.19
	$d_1/d_2 = 1/2$	0.56
	$d_1/d_2 = 1/4$	0.92
ordinary outlet:	$d_1/d_2 = 0$	1.00
Sudden contraction (use downstream velocity for V):	$d_2/d_1 = 3/4$	0.25
	$d_2/d_1 = 1/2$	0.43
	$d_2/d_1 = 1/4$	0.49
ordinary inlet:	$d_2/d_1 = 0$	0.50
Rounded, or bell-mouth, inlet:		0.001
Borda inlet:		0.75
Gate valve, fully open:		0.25

6. Critical Depth in Open Channel Flow

In rectangular open channels, the flow is called "critical" when the Froude number is unity:

$$F = \frac{v}{\sqrt{gy}} = 1 \qquad (6\text{-}1)$$

where v is the average flow velocity, g is the gravitational acceleration, and y is the water depth.

Subcritical flow, where F is less than 1, is the relatively quiescent flow upstream of weirs, or found in long channels with mild slope, and downstream of full hydraulic jumps. Supercritical flow, in which F is greater than 1, is the "shooting flow" often seen downstream of weirs and sluice gates, often characterized by oblique (or "diamond-pattern") fixed waves.

In rectangular channels, critical depth and critical velocity for a given flow, Q, are easily computed from Equation (6-1):

$$Q = UBy; \qquad U_c = \sqrt{gy_c} \quad \text{for} \quad F = 1 \qquad (6\text{-}2)$$

$$Q/B = U_c y_c = y_c \sqrt{gy_c} = g^{0.5} \; y_c^{1.5} \qquad (6\text{-}3)$$

$$y_c = g^{-1/3} (Q/B)^{2/3}; \; U_c = (g \; Q/B)^{1/3} \qquad (6\text{-}4)$$

However, for a channel that does not have a simple unambiguous depth like a rectangular channel, the definition of critical flow conditions is a little more complex.

Recall from Section 4 that the specific energy, E, is the sum of potential and kinetic energy:

$$E = y + \frac{v^2}{2g} \qquad (6\text{-}6)$$

Express velocity, v, as flow per unit of cross-sectional area: $v = Q/A$:

$$E = y + \frac{(Q/A)^2}{2g} \qquad (6\text{-}7)$$

Since A is a function of depth, y, the plot of E against y appears as in Example 3. For all conditions but critical, there can be two values for y for each value of E; subcritical and supercritical. The critical condition is found when E(y) is a minimum, i.e., when dE/dy = 0:

$$dE/dy = 1 + \left(\frac{Q^2}{2g}\right)\left(\frac{-2}{A^3}\right)\frac{dA}{dy} \qquad (6\text{-}8)$$

$$= 0 \quad \text{when} \left(\frac{Q^2}{gA^3}\right)\left(\frac{dA}{dy}\right) = 1 \qquad (6\text{-}9)$$

Now, dA/dy is simply the width of the channel at the water surface; call it "b":

$$\text{For critical conditions,} \quad \frac{Q^2 b}{gA^3} = 1 \qquad (6\text{-}10)$$

Equation (6-10) is then the general equation for critical flow conditions in a channel of any cross-section. To check its agreement with Equations (6-1) to (6-3) for rectangular channels, set y = A/b and Q/A = U.

For practical problems of solving for critical depth of a known dischage, Q, in a circular part-full pipe or a trapezoidal channel, Chow * has published a chart giving critical depth in terms of diameter (d_0) or bottom width, b, and side slope, and the parameter

$$Z = Q / \sqrt{g} = A \sqrt{A/b} \qquad (6\text{-}11)$$

See Figure 6-1.

*Ven Te Chow, Open-Channel Hydraulics, McGraw-Hill, 1959.

7. Free-Surface Weirs

Weirs regulate the rate at which passes over them, and provide a convenient means of flow measurement. For many cases of interest, the flow passes through a critical flow condition. Therefore, weir formulas are all related to Equation 6-10 in one way or another. Several common weir configurations are illustrated, and their formulas given, in Figure 7-1.

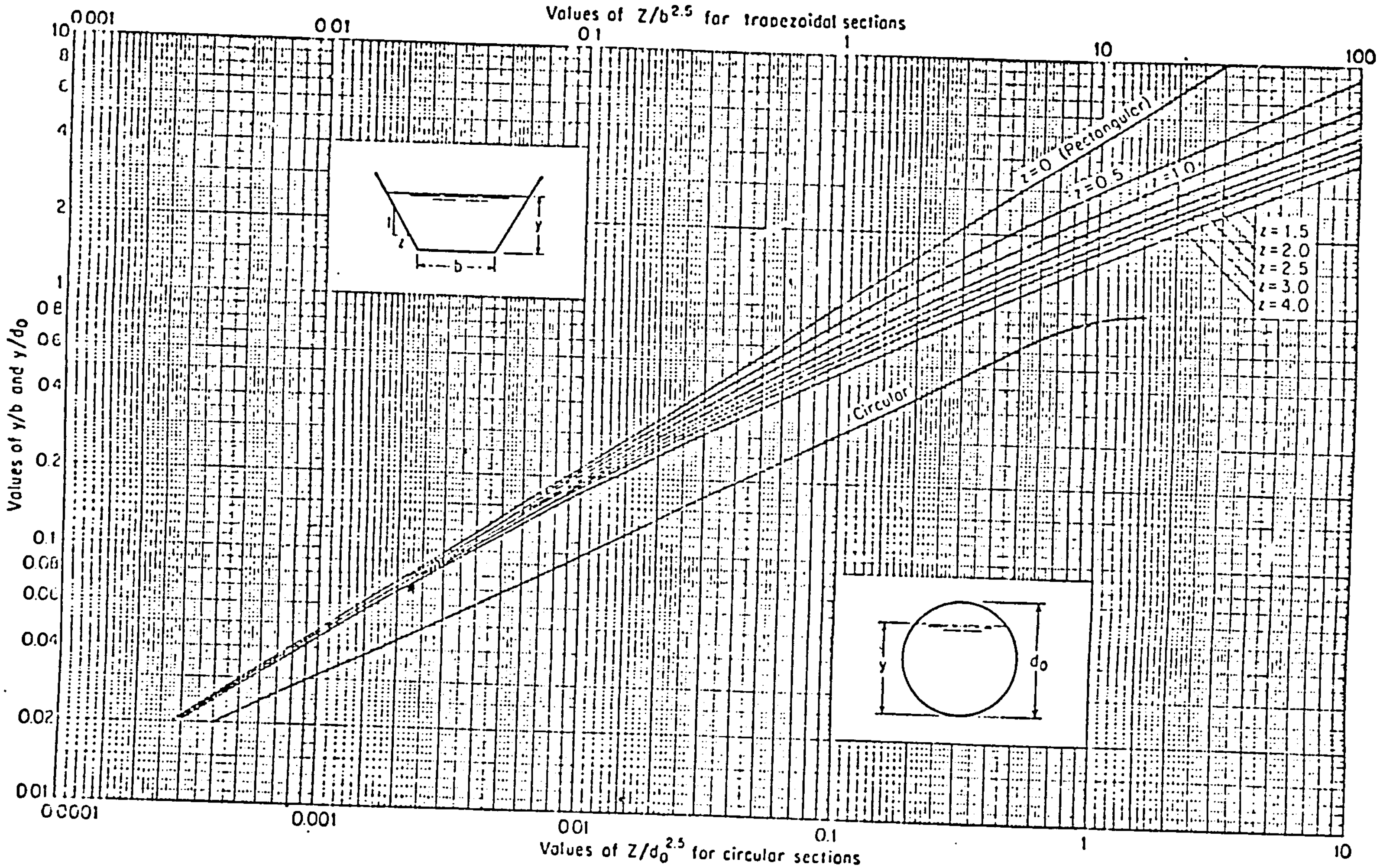
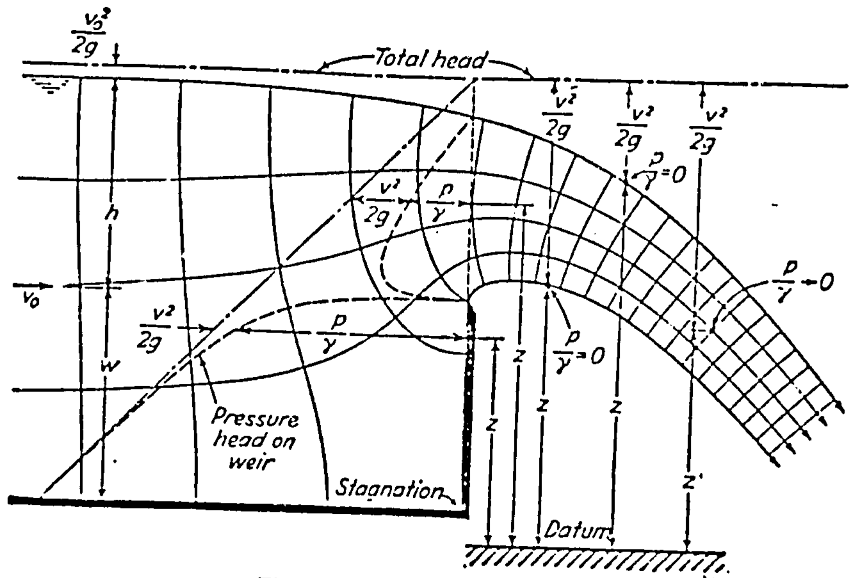


FIGURE 6-1. Curves for Determining the Critical Depth. (From V.T. Chow, Open-Channel Hydraulics, McGraw-Hill, 1959).

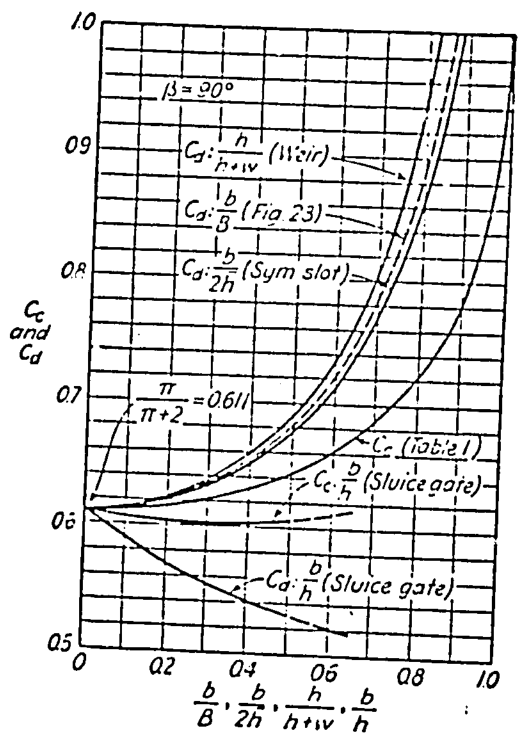
15,89



Flow net for gravity discharge over a weir. *

Rectangular weirs:

$$Q = C_d \frac{2}{3} \sqrt{2g}\, L\, h^{3/2}$$



Variation of coefficients with boundary form. *

Triangular weirs, in F-P-S units:

$$Q = 2.5\, H^{2.5}$$

Figure 7-1.

* Rouse, Engineering Hydraulics, Wiley, 1950.

9. Cavitation

Cavitation is the formation and subsequent collapse of vapor-filled cavities in a liquid due to dynamic fluid motion. Cavitation bubbles are formed when fluid pressure drops below the fluid vapor pressure. This can happen when:

--hydrostatic pressure is low, and

--high fluid speed reduces the pressure yet further.

Zones of high fluid can be at the tips of pump impeller blades, for example, or in sharp pipe bends.

Vapor bubbles generated in local zones of great fluid speed are carried away from their point of generation to a zone of lesser fluid speed, hence greater fluid pressure. With greater fluid pressure, the vapor in the bubble condenses, and the bubble collapses and vanishes. The fluid-vapor walls of the bubble rush inward and collide with great velocity at the center of the vanishing bubble.

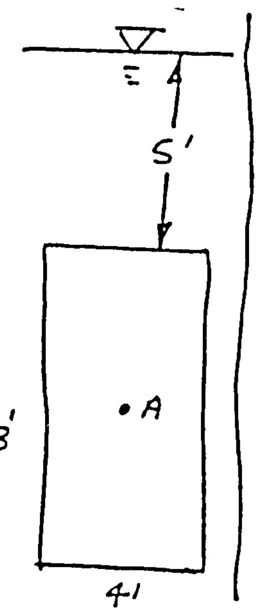
With collapse and collision of the bubbles, a great deal of energy is concentrated in a very small volume. Shock waves in the water radiate out from the point of collapse. These shock waves have the capability of digging holes or pits in metal. Over a period of time, considerable damage can be done to pumps and pipes.

A pump acting under cavitation conditions sounds as if it is pumping gravel. Cavitation can be reduced or avoided by:

- -- increasing the hydrostatic head of the flow by increasing the available net positive suction head (NPSH)
- -- reducing the flow velocity where cavitation occurs by eliminating pipe bends upstream of the cavitation location.

EXAMPLES

1. A rectangular panel, 4' wide x 8' tall, in a vertical wall, is submerged 5 ft below the water surface as shown in the diagram. What is the gauge pressure at the center of the door, Point A? What is the hydrostatic force on the door?



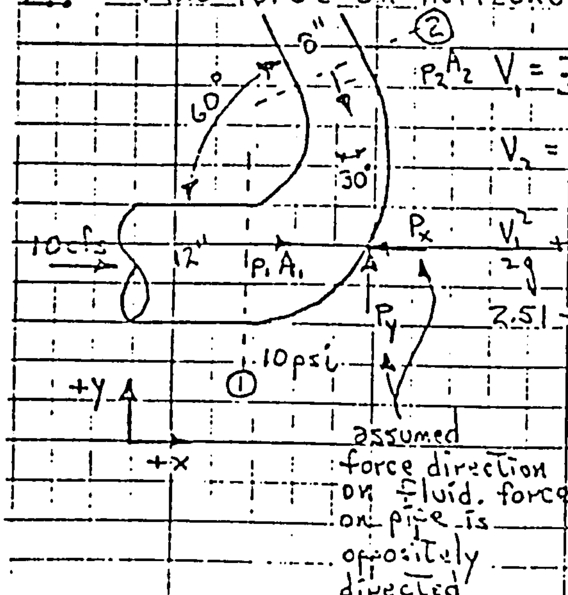
-- Point A is $5 + \frac{8}{2} = 9$ ft below the surface. $P = \rho g h = 62.4 \frac{lb}{ft^3} \times 9 ft =$

$\underline{561.6\ lb/ft^2}$

--- Force is pressure at the centroid x panel area:

$561.6\ lb/ft^2 \times 32\ ft^2 = \underline{17971.2\ lb}$

2. Find force on horizontal pipe bend shown below. Neglect friction loss.



$V_1 = \frac{10}{\frac{\pi}{4}(1)^2} = 12.72$ fps $V_1^2/2g = 2.51$ ft $A_1 = \frac{\pi}{4} 12^2 = 113\ in^2$

$V_2 = \frac{10}{\frac{\pi}{4}(.67)^2} = 28.6$ fps $V_2^2/2g = 12.70$ ft $A_2 = \frac{\pi}{4} 8^2 = 50.2\ in^2$

$$\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + 0 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + 0$$

$$2.51 + \frac{10(144)}{62.4} = 12.70 + \frac{P_2(144)}{62.4} \quad \therefore \quad P_2 = 5.57\ psi$$

$$\Sigma F_x = \rho Q (V_{out} - V_{in})_x$$

$$P_1A_1 + P_2A_2 \sin 30° - P_x = \rho Q(-V_2 \sin 30° - V_1)$$

$$10(113) + 5.57(50.2)(0.5) - P_x = 1.94(10)[-28.6(0.5) - 12.72]$$

$P_x = {}^{+}1790 \leftarrow$

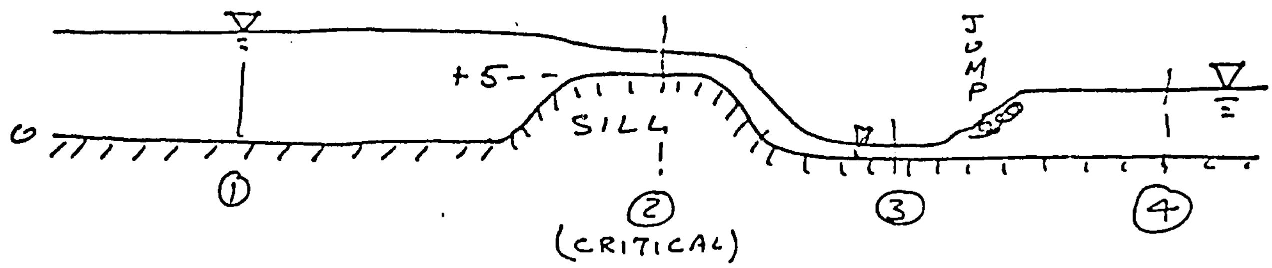
$$\Sigma F_y = \rho Q (V_{out} - V_{in})_y$$

$$P_y - P_2A_2 \cos 30° = \rho Q (V_2 \cos 30°)$$

$$P_y - 5.57(50.2)(.866) = 1.94(10)(-28.6)(0.866)$$

$P_y = {}^{+}734 \uparrow$

3. In a 1-ft wide channel approaching a sill, the floor elevation is zero. The sill elevation is +5. The 1-ft wide channel downstream of the sill also has floor elevation zero.



Flow passing over the sill has a critical depth of 1 ft.

a. What is the flow-rate?

b. What is the water depth at ①?

c. What is the water depth in supercritical flow at ③?

d. What is the water depth at ④, downstream of a stationary hydraulic jump?

Neglect friction losses other than energy loss in the jump.

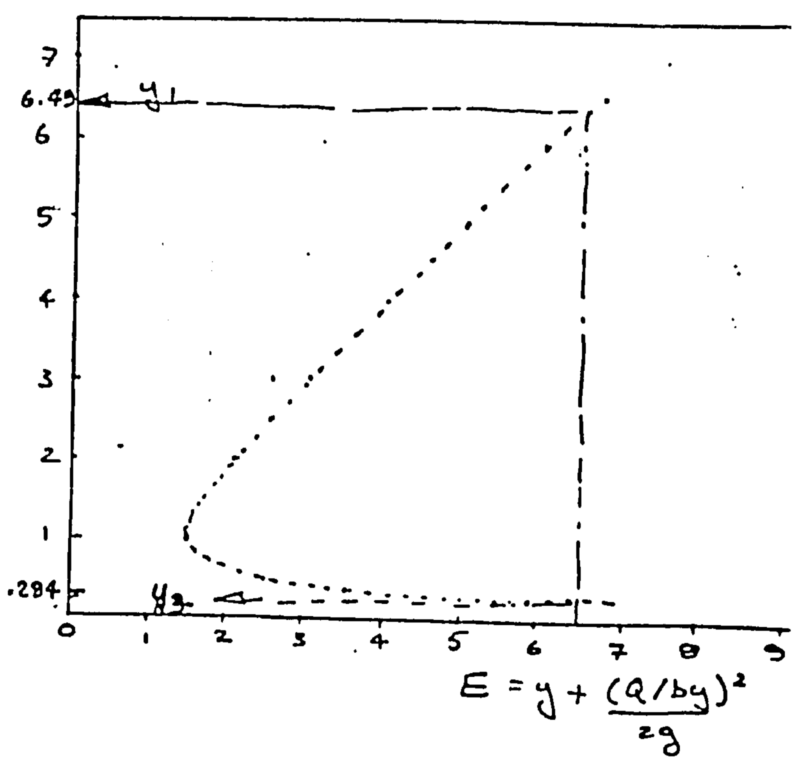
a. $Q = bVy$; $b = 1$ ft ; at ②, critical conditions exist : $V_c = \sqrt{g y_c}$; $y_c = y_2 = 1$ ft ; $Q = 1 \times \sqrt{32.2 \times 1} \times 1 = \underline{5.67 \text{ cfs}}$

b. The specific energy is $E = y + \frac{V^2}{2g} = y + \frac{[Q/(by)]^2}{2g}$

Construct the specific energy curve y vs E, for this Q and b.

At ②, y = 1, so E = 1.5 ft.

The energy grade line is thus at elevation 1.5 + 5 ft. Since there is no friction loss between ① and ②, The EGL is at 6.5 ft at ① and ③ as well as ②.



2541

3 (cont'd)

Since the floor at ① and ③ is at Elevation zero, The specific energy at ① and ③ is 6.5 ft. From the curve, deduce two values of y for E = 6.5: the greater, for subcritical flow, is $\underline{y_1 = 6.49 ft}$. The lesser, for supercritical flow, is $\underline{y_3 = .284}$.

To determine y_4, apply the momentum equation:

$$\rho g \frac{y_4^2}{2} + \rho Q V_4 = \rho g \frac{y_3^2}{2} + \rho Q V_3$$

$$\frac{g}{2} y_4^2 + \frac{Q^2}{b y_4} = \frac{g}{2} y_3^2 + \frac{Q^2}{b y_3}$$

$g = 32.2\ ft/sec^2$; $Q = 5.67$ cfs; $b = 1 ft$; $y_3 = 0.284 ft$

$$\frac{32.2}{2} y_4^2 + \frac{(5.67)^2}{1 \times y_4} = \frac{32.2}{2}(.284)^2 + \frac{(5.67)^2}{1 \times .284}$$

$$(16.1) y_4^2 + \frac{(5.67)^2}{y_4} = 1.30 + 113.2 = 114.5$$

By trial and error:

Try y_4:	$\frac{32.2}{2} y_4^2 + \frac{(5.67)^2}{y_4} = 114.5$?
5	408.9
3	155.6
2	80.5
2.5	113.5
2.51	114.2 → use this:

$\underline{y_4 = 2.51 ft}$

4. What size must a v.c. sewer be to carry 4 cfs, assuming a grade necessary to produce $V = 2$ fps when flowing full?

$Q = AV = 4\text{ cfs} = (\frac{\pi}{4}D^2) \times 2$; $\therefore D = 1.60\text{ ft} = 19.2\text{ in}$

(Use 18 inch diameter for $V > 2$ fps)

What is the slope for this pipe if the Manning $n = 0.013$

If $D = 18$ inches $= 1.5$ ft, then $A = \frac{\pi}{4}(1.5)^2 = 1.77\text{ ft}^2$

$V = 4\text{ cfs} / 1.77\text{ ft}^2 = 2.25$ fps ; $V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$S = \left[\frac{V^2 n^2}{1.49^2 \, R^{4/3}}\right] = 0.00142$; $R = (1.5/4)$;

5. Two 24-inch dia. reinforced concrete drains, at a slope of 0.0025 discharge into a long rectangular open channel of width 5 ft and slope of 0.004. What is the normal depth of flow when the drains are flowing full without surcharge? Use $n = .013$.

a. $Q = 2 \times \left[\frac{1.49}{n} A R^{2/3} S^{1/2}\right] = 2 \times \left[\frac{1.49}{.013} \times \frac{\pi (2)^2}{4} (2/4)^{2/3} \sqrt{.0025}\right]$ (2 drains)

$= 22.7$ cfs

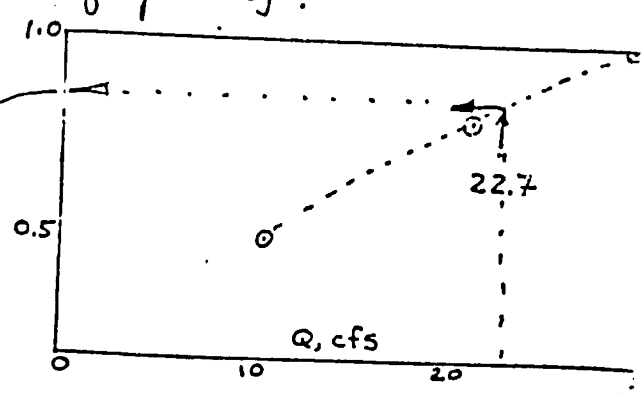
b. Find normal depth, y, in open channel.

$A = 5y$; $R = A/P = 5y/(5+2y)$; $Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$

Solve by trial-and-error, and graphically:

Trial y	Resulting $AR^{2/3}$	Resulting Q
0.5 ft	1.395	10.11 cfs
1.0	3.995	28.96
0.8	2.865	20.77
0.85	3.138	22.74 cfs - confirmed

(confirm)



6. Compute the rectangular "best hydraulic section" to convey a flow of 17 m^3/sec. The wall material is smooth concrete, and the slope is 0.08m per 1000 m.

A "best hydraulic section" has the least wetted perimeter for a given cross-sectional area. For a rectangular channel, the BHS is one in which the flow depth, y, is half of the width.

Use the Manning formula for SI units:

$$Q = \frac{1}{n} AR^{2/3} S^{1/2}$$

For smooth concrete, use n = 0.013

$S = 8\times10^{-5}$

$Q = 17\ m^3/sec$

$A = 2y^2$

$R = A/P = 2y^2/4y = y/2$

$$AR^{2/3} = 1.26y^{2.667}$$

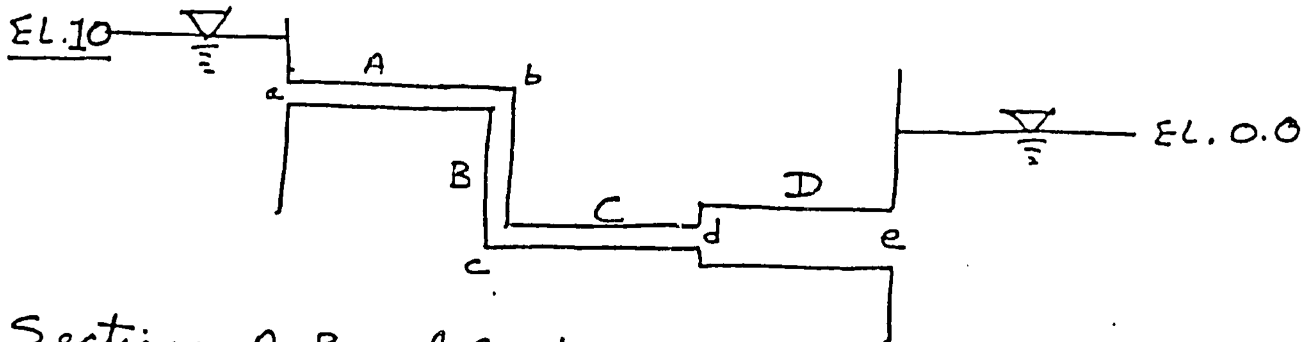
But $AR^{2/3} = Qn/S^{1/2} = 24.7$

$y = (24.7/1.26)^{\frac{1}{2.667}} =$ 3.05m the depth

The width is 2y, or 6.1m.

EXAMPLES 7, 8 OMITTED.

9. A pipeline connecting two reservoirs consists of four sections, each 1000 m long.



Sections A, B, and C have 0.1 m diameter; Section D has 0.2 m diameter. For Manning n = 0.013, what Q in the system results from a 10 m head difference?

Friction: $Q = \frac{1}{n} A R^{2/3} S^{1/2}$, or

$$h = \frac{L Q^2 n^2}{A^2 R^{4/3}}$$

L = 1000 m, n = .013. For A, B, C,

$A = \frac{\pi}{4}(.1)^2$, $R = 0.025$

$h_A = h_B = h_C = 374789 Q^2$

For D, $A = \frac{\pi}{4}(.2)^2$, $R = .05$

$h_D = 9296 Q^2$

Total friction loss $= h_A + h_B + h_C + h_D$

$= 1,133,663 Q^2$

Form: $h = K \frac{Q^2}{A^2 2g}$; g = 9.

At a: K = 0.5, $A = \frac{\pi}{4}(.1)^2$; $h_a = 414$

b, c: K = 1.0, $A = \frac{\pi}{4}(.1)^2$; $h_b = h_c$

$h_b = h_c = 827$

d: K = 0.56, $A = \frac{\pi}{4}(.1)^2$;

$h_d = 463$

e: K = 1.0, $A = \frac{\pi}{4}(.2)^2$;

$h_e = 52$

Total form loss =

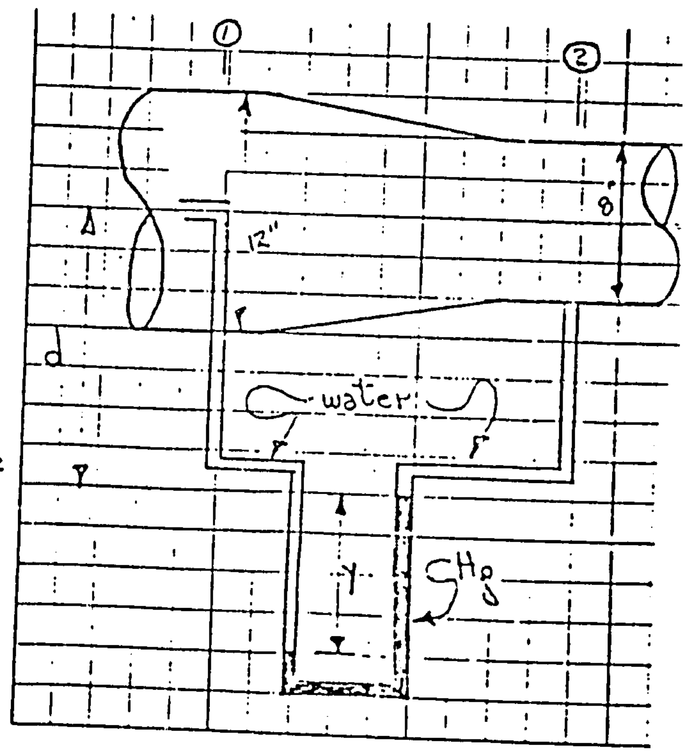
$h_a + h_b + h_c + h_d + h_e = 2583 Q^2$

Form loss + friction loss $= 1,136,246 Q^2 = 10$ m

$Q = 0.00297$ cms = <u>2.97 litres/sec.</u>

13. Given the tubing configuration shown below, find the deflection, y, for a flow of 10 cfs. Assume that the centerline velocity is 1.5 times the average velocity. Neglect headloss in the pipe contraction. The specific gravity of mercury is 13.6.

... The tube at (1) measures total head at the pipe centerline. The tube at (2) measures piezometric head.



$$\frac{V_{1avg}^2}{2g} + \frac{P_1}{\rho g} + Z_1 = \frac{V_{2avg}^2}{2g} + \frac{P_2}{\rho g} + Z_2$$

$$Z_1 = Z_2$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = \frac{V_{2avg}^2}{2g} - \frac{V_{1avg}^2}{2g}$$

$$V_{1avg} = \frac{10}{\pi(1^2)} = 12.72 \text{ fps}; \quad \frac{V_{1avg}^2}{2g} = 2.51 \text{ ft}$$

$$V_{2avg} = \frac{10}{\pi(.67)^2} = 28.6 \text{ fps}; \quad \frac{V_{2avg}^2}{2g} = 12.70 \text{ ft}$$

$$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 12.70 - 2.51 = 10.19 \text{ ft of water.}$$

The total head at (1) is $\frac{P_1}{\rho g} + \frac{(1.5 V_{1avg})^2}{2g}$; the piezometric head at (2) is $\frac{P_2}{\rho g}$. The difference is $10.19 + (1.5)^2 \cdot 2.51 = 15.84$ feet of water. As for y, $15.84 \text{ ft}_{H_2O} + 1 \times y \text{ ft}_{H_2O} = 13.6 y \text{ f}$

$$15.84 = 12.6 y; \quad \underline{y = 1.26 \text{ ft}}$$

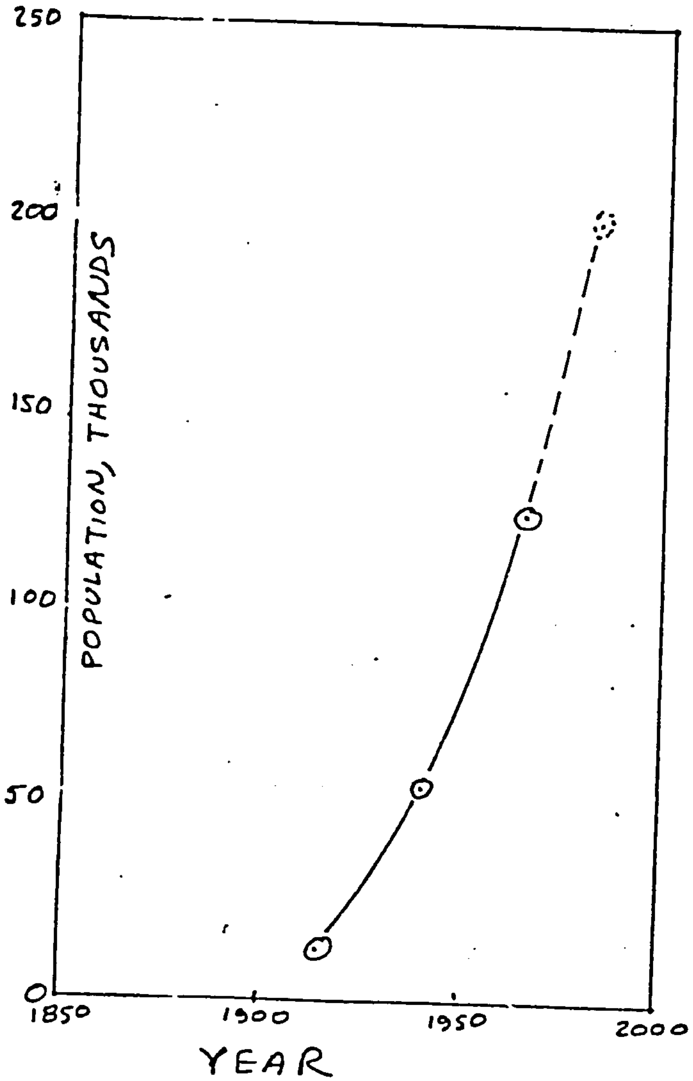


FIGURE 17.

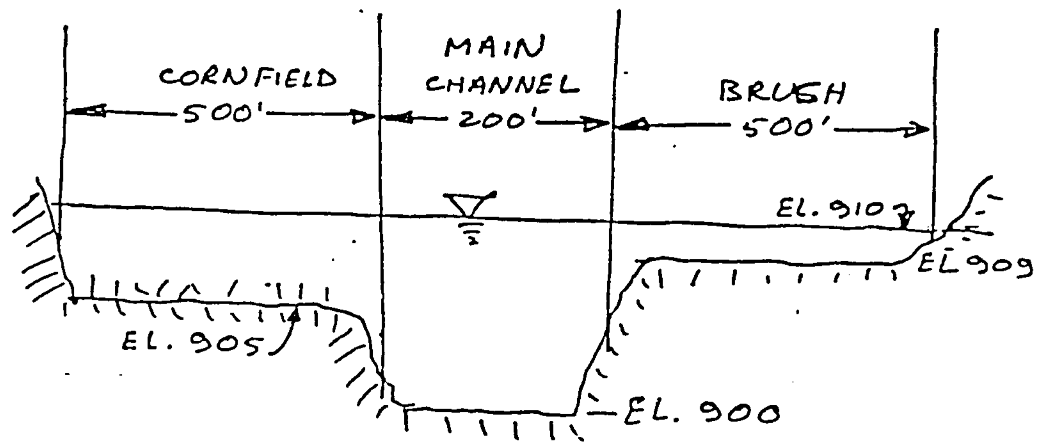


FIGURE 18.

Thus, for the cornfield:

n = 0.06, depth = 910-905 = f ft, A = 500x5 = 2500 ft,^{2}

R = 5 ft;

$$Q = \frac{1.49}{0.06} \times 2500 \times 5^{2/3} \times (.00031)^{0.5}$$

<u>Q = 3196 ft^3.sec (cornfield)</u>.

For the main channel:

n = 0.015, depth = 910-900 = 10 ft, A = 200x10 = 2000 ft^2,

R = 10 ft;

$$Q = \frac{1.49}{.015} \times 2000 \times 10^{2/3} \times 0.00031^{0.5}$$

<u>Q = 16236 ft^3/sec (main channel)</u>.

For the brush-covered area:

n = 0.12, depth = 910-909 = 1 ft, A = 500x1 = 500 ft^2,

R = 1 ft;

$$Q = \frac{1.49}{0.12} \times 500 \times 1^{2/3} \times (.00031)^{0.5}$$

<u>Q = 109 ft^3/sec (brush)</u>.

The sum of these three discharges is the <u>total discharge: 19-41 ft^3.sec.</u> The sum of the three areas is 5000 ft^2; <u>the average velocity is the total discharge divided by the total area, or 3.9 ft/sec</u>.

(NOTE: even in cases where one explicitly considers the rigid banks of the flow, the vertical interface between two sections of the flow, e.g., between the flow covering the cornfield and the flow in the main channel, should <u>not</u> be considered a frictional surface. The cornfield flow may exert a slowing drag on the main channel flow; but the main channel flow exerts an equal and opposite impulsive drag, or boost, to the cornfield flow, for zero net effect.)

HYDRAULICS GLOSSARY

Uniform flow has the same speed and direction at all points within the flow boundaries. Uniform flow need not be steady flow.

Steady flow has speed and direction that may vary from point to point, but which nowhere changes speed or direction with respect to time.

Rapidly varied flow is open-channel flow that changes speed and/or direction suddenly, due to channel geometry such as a bend or a sill, or due to a hydraulic jump.

Gradually varied flow is open-channel flow that changes depth and speed in adjustment to wall friction force on the fluid. Examples are backwater and drawdown.

Piezometric head, representing the amount of potential energy in a flow, is the free surface elevation in open-channel flow. In a full closed conduit, the piezometric head is the elevation to which fluid would rise in a test bore piercing the conduit wall.

Hydraulic Grade Line (HGL) is the locus of piezometric head all along a flow conduit.

Velocity Head, $v^2/2g$, is a measure of kinetic energy in the flow.

Total Head is the sum of piezometric head and velocity head.

Specific Energy is the elevation of total head above the channel floor at any point.

The Energy Grade Line (EGL) is the locus of total head all along a flow conduit.

Froude Number, $F = V/\sqrt{gy}$. In critical flow, F=1. In supercritical flow, F is greater than 1. In subcritical flow, F is less than 1.

Critical Depth: For a given channel size and shape and a given flow rate, the depth at which flow is critical. See Section 6.

Normal depth in open-channel flow is achieved in a long straight channel of uniform wall roughness and channel geometry. In normal-depth flow, energy dissipation by side-wall fricition is equal to the decrease in potential energy as fluid proceeds down a channel. Put another way, friction slope, S, calculated from the Manning formula from Q, n, R, and A, just equals the longitudinal channel slope.

Hydraulic Radius: the ratio of flow cross-section area to wetted perimeter: $R = A/P$. For a very wide, shallow rectangular channel, R is approximately equal to the channel depth. For a circular pipe flowing full, R = 1/4 times the diameter.

Best Hydraulic Section: For a given flow area, the channel section that has the least wetted perimeter, hence the greatest conveyance. For a rectangular channel, the BHS is half of a square (width equal to twice the depth).

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: November 8 & 12

TIME: 1 Hr. 20 Min.

COMPONENT: Groundwater/Wastewater

SESSION: 11. Control of high groundwater levels

SESSION OBJECTIVES:

To describe some methods for controlling high groundwater levels.

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Control of High Groundwater Levels

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
NOTE: (40 min for 1- 6	1. Describe the drainage field method used on farmlands. Suggest modified systems for villages. French drains.	Prepare sketch on flip chart Refer to "Water for the World" Techn. Note No. SAN 1.C.7. page 3, figure 4; page 8, figure 11; page 9, figure 12.

98

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Describe impermeable linings and cut-off walls to stop seepage from canals and drains. Concrete, clay, plastic sheeting, etc.	Prepare sketch on flip chart.

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	4. Grading of streets and pathways to provide good surface water drainage. 5. Installation of sewers to drain away sewage and wastewater. 6. Others?	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	7. Ask participants to think for a few minutes about which of the previously discussed methods would be most usable in their situation. Then, divide them into work groups and ask them to select the most desirable control methods and to be prepared to give their reasons for choosing these. Tell them to outline their ideas on the flip chart and to be prepared to share them in 20-25 minutes.	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	8. Let each group report out.	
15 min.	Conclude by using their lists to identify the most practical and useful solutions for controlling high groundwater levels.	

HANDOUT: GW-5-A

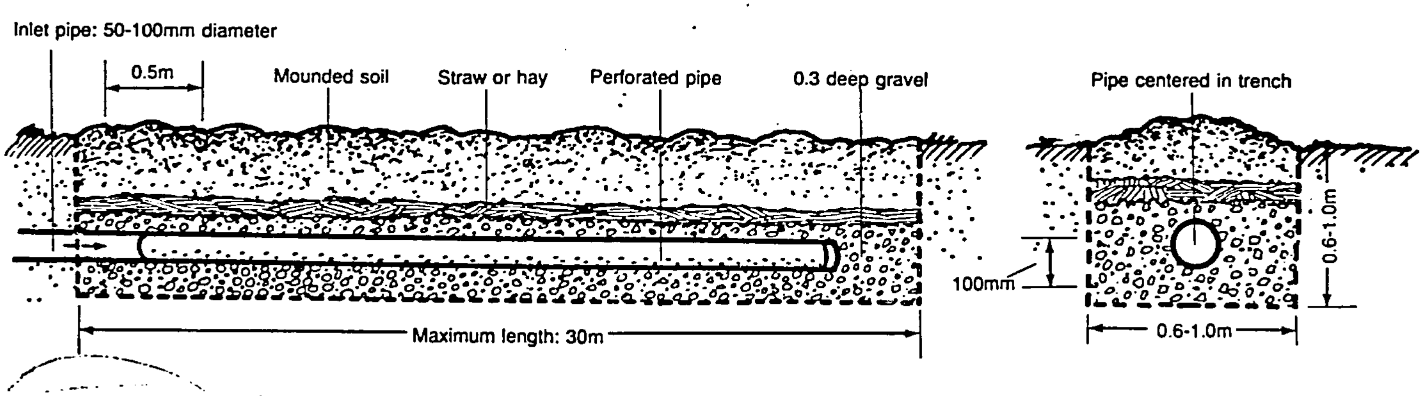


Figure 4. Soakage Trench

103

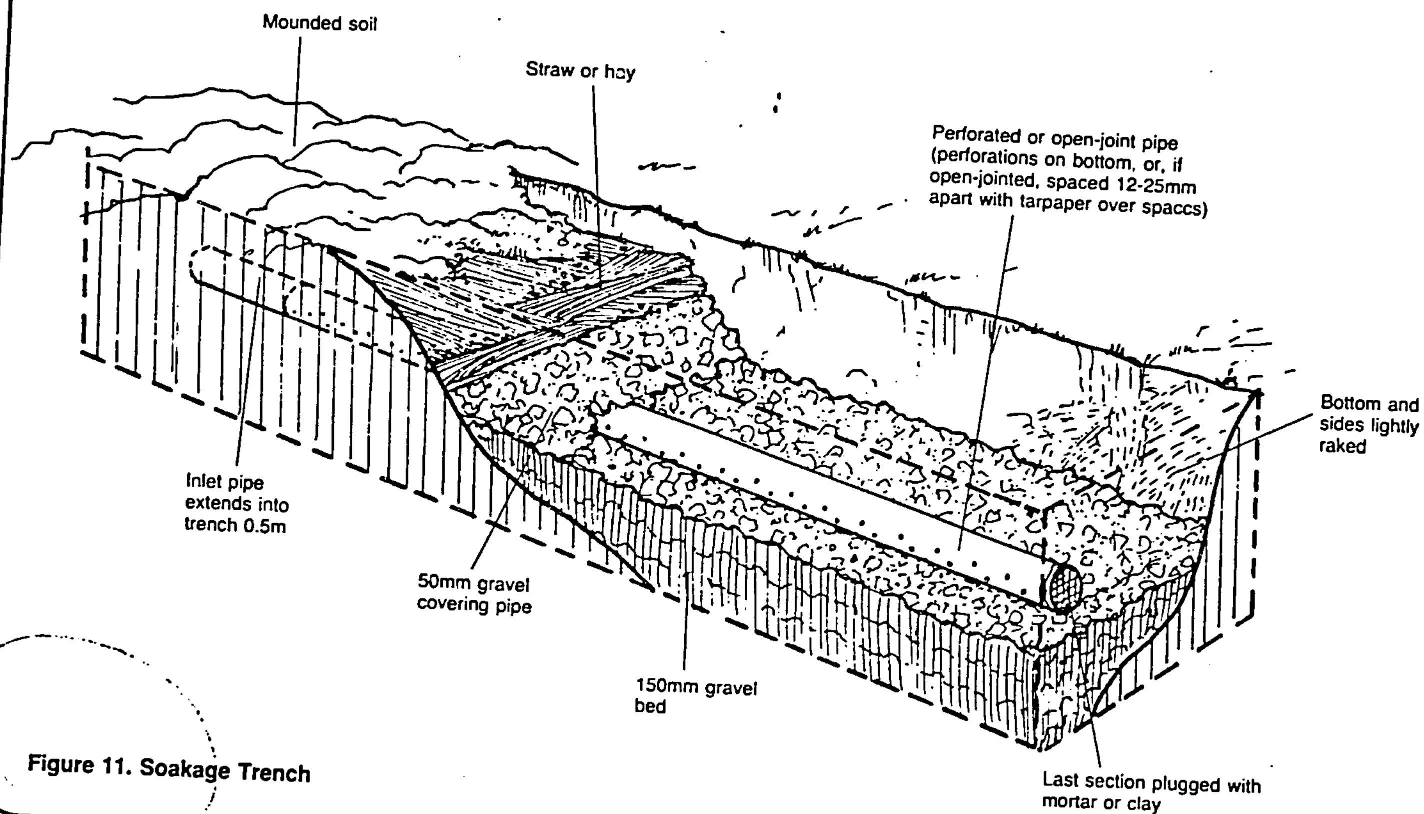


Figure 11. Soakage Trench

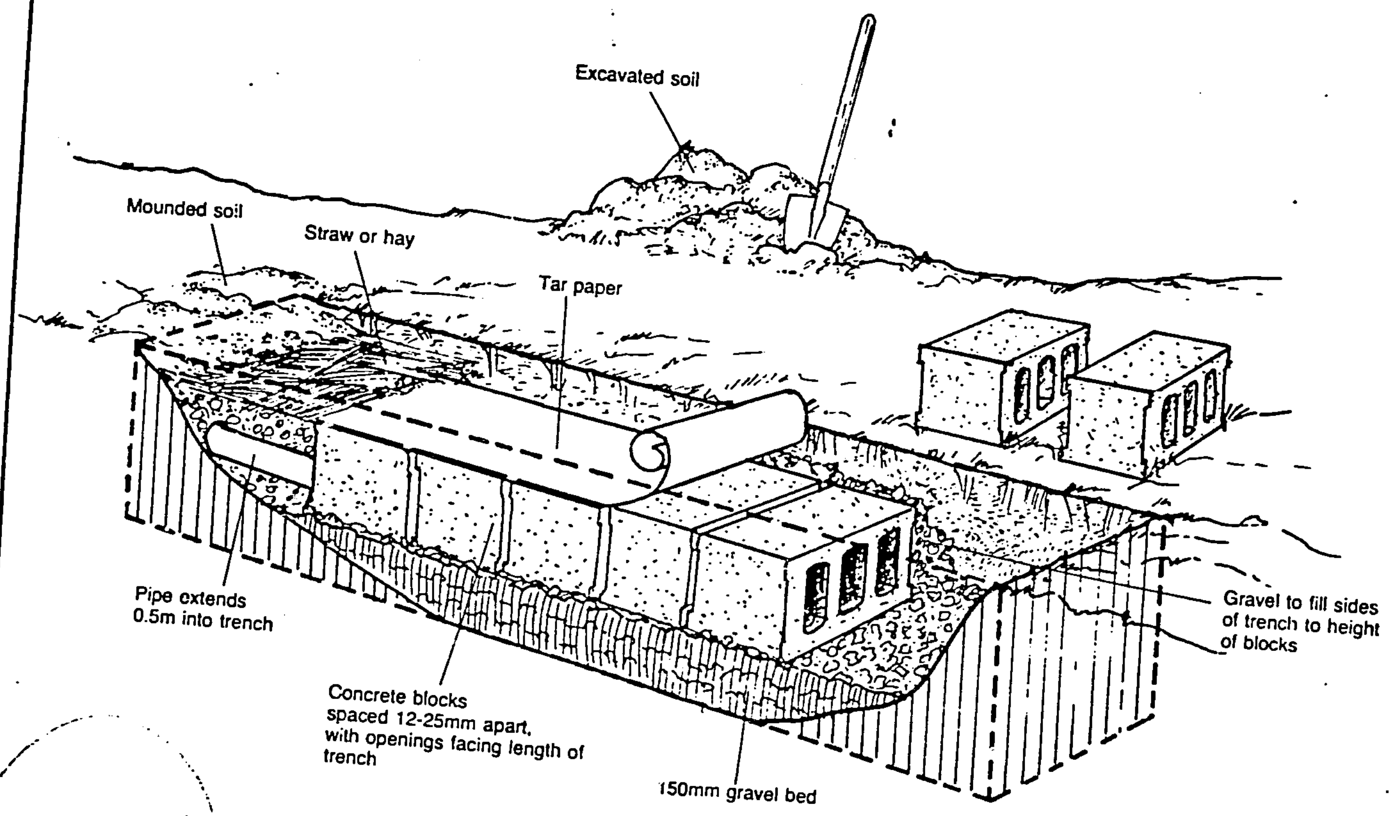


Figure 12. Soakage Trench Using Concrete Blocks

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 9

TIME: 2 Hours 30 Min

COMPONENT: Water Supply

SESSION: 12. Pumps

SESSION OBJECTIVES:

1. To review the types of centrifugal pumps and their performance.
2. To describe how to select a pump, by its performance, to match a service need.
3. To examine the problems of cavitation and water hammer, and develop suggestions as to how to solve them.

TECHNICAL COMPONENT: Water Supply

SESSION: Pumps

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
15 min	1. Facilitate a discussion about how participants determine the range of specifications of pumps in operation within their regions. (Rate H and Q, type, number in station, fixed speed or variable speed?)	Pump Handbook, by Karassik et al., McGraw-Hill, 1976.

TECHNICAL COMPONENT: Water Supply

SESSION: Pumps

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
60 min	2. Present a short lecturette on: o Types of pumps o Theory of operation o Head-discharge curves, showing impeller speed and pump efficiency o Selecting pumps for a particular system-head discharge curve (or curves, if there are pumps elsewhere in the system). o Pumps in series and in parallel. Specific speed.	

TECHNICAL COMPONENT: Water Supply

SESSION: Pumps

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	3. Present a short lecturette on cavitation that covers: o Definition : when it occurs o Damage it can cause in impeller and casing o Control by providing good approach flow conditions and adequate available NSPH o Sounds like gravel being churned in the pump	

TECHNICAL COMPONENT: Water Supply

SESSION: Pumps

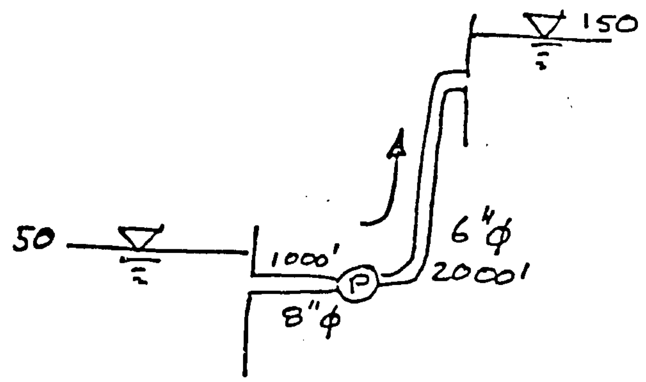
TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	4. Facilitate a discussion about water hammer. Introduce the discussion with a brief statement of what it is, when it occurs, symptoms, and possible damage. Trade stories of water-hammer problems and how they were handled.	

TECHNICAL COMPONENT: Water Supply

SESSION: Pumps

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	5. Conclude with a lecturette about water hammer that covers: o Qualitative description of downsurge and upsurge propagating along a pipeline upon sudden change in flow rate. o Description of techniques of analysis, graphical and computational.	

10. A pump delivers 2.5 cfs from the reservoir at elev. 50 to a reservoir at elev. 150. There is 1000 ft of 8" suction pipe and 2000 ft of 6" of discharge pipe. Deduce the horsepower of the pump. Neglect form losses. Water temperature is 70 °F. The roughness is ε = 0.001 ft, and the pump efficiency is 0.8



Bernoulli equation applied between two reservoirs:

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_{f_{8''}} + h_{f_{6''}} - h_{Pump}$$

$$0 + 0 + 50 = 0 + 0 + 150 + h_{f_{8''}} + h_{f_{6''}} - h_{pump}$$

In 8" pipe:

$$V_8 = \frac{2.5}{\frac{\pi}{4}(.67)^2} = 7.16 \text{ fps} \qquad \frac{V_{8''}^2}{2g} = 0.793 \text{ ft}$$

$$\mathbb{R} = \frac{VD}{\nu} = \frac{7.16 \times 0.67}{1.095 \times 10^{-5}} = 4.5 \times 10^5, \qquad \frac{\varepsilon}{D} = \frac{.001}{.67} = .0015$$

From Figure 5-1, $f_{8''} = 0.022$

$$h_{f8''} = \frac{f_{8''} L_{8''}}{D_{8''}} \frac{V_{8''}^2}{2g} = \frac{0.022 \times 1000}{0.67} \times 0.793 = 26 \text{ ft}$$

In 6" pipe:

$$V_6 = \frac{2.5}{\frac{\pi}{4}(.5)^2} = 12.72 \text{ fps} \qquad \frac{V_{6''}^2}{2g} = 2.50 \text{ ft}$$

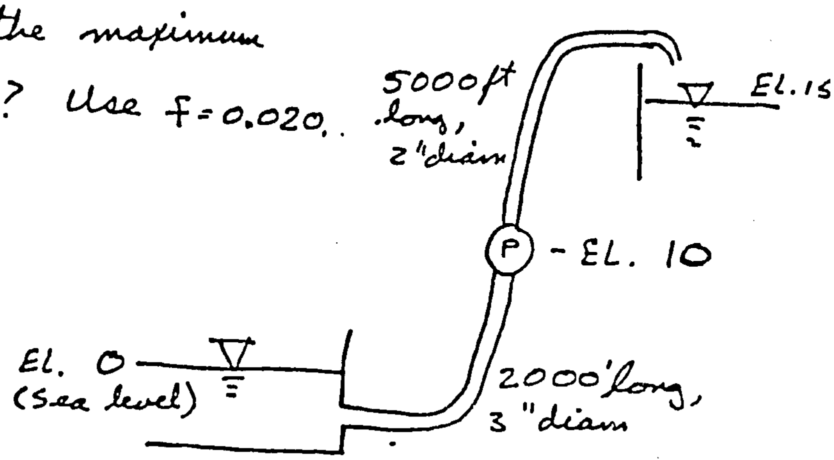
$$\mathbb{R} = \frac{VD}{\nu} = \frac{12.72 \times 0.5}{1.059 \times 10^{5}} = 6 \times 10^5; \qquad \frac{\varepsilon}{D} = \frac{.001}{0.2} = .002$$

From Figure 5-1, $f_{6''} = 0.024$

$$h_{f6''} = \frac{f_6 L_6}{D_6} \frac{V_6^2}{2g} = \frac{0.024 \times 2000}{0.5} \times 2.5 = 240 \text{ ft}$$

$$h_{pump} = (150 - 50) + 26 + 240 = 366 \text{ ft} \qquad hp = \frac{\rho g Q h_{pump}}{550 e} = 130 \text{ horsepower}$$

11. For the pumping system shown, what is the maximum possible flow rate? Use $f = 0.020$.



(In the past, some students have declared that there is insufficient information given. Resist jumping to that conclusion!)

This example differs most from No. 10 in that the pump is located <u>above</u> the suction reservoir level. The pump will not function if absolute pressure, P_a, is less than zero:

$$P_a = P_{atm} - \rho g (10) - \rho g \left(\frac{fL}{D} \frac{V^2}{2g} \right)$$

At sea level, $P_{atm} = 14.7 \text{ psi} = \rho g (34 \text{ ft})$

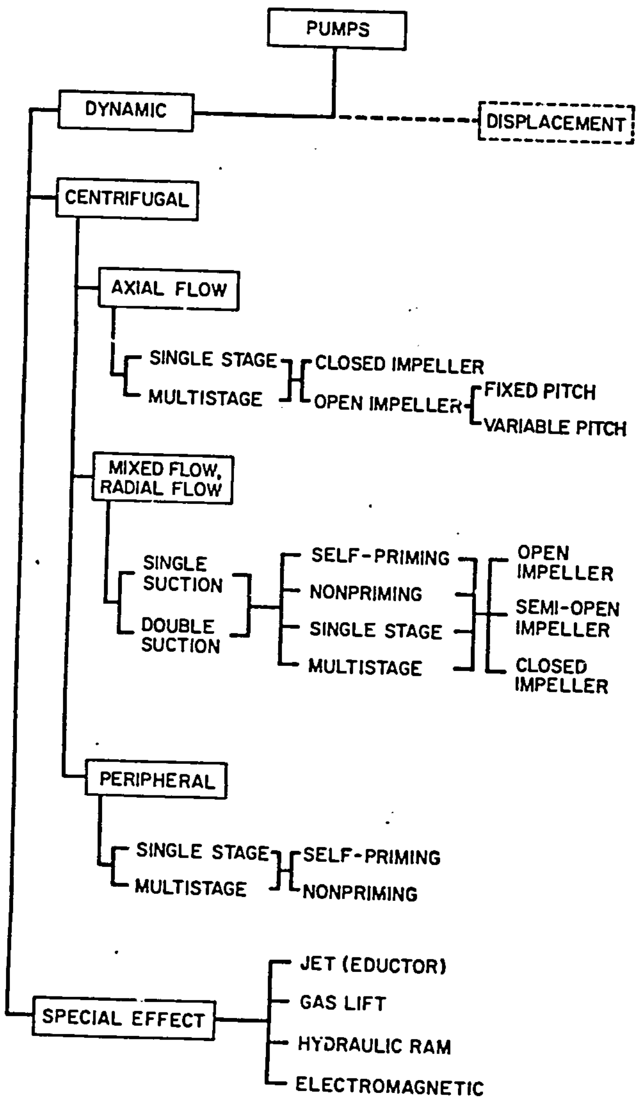
$$P_a = 0 = \rho g \left[34 - 10 - \frac{(0.02)(2000')}{0.25'} \frac{V^2}{2(32.2)} \right]$$

$V = 4.21$ ft/sec; $\quad Q = \frac{\pi}{4} D^2 \times V = \underline{0.207 \text{ cfs}}$

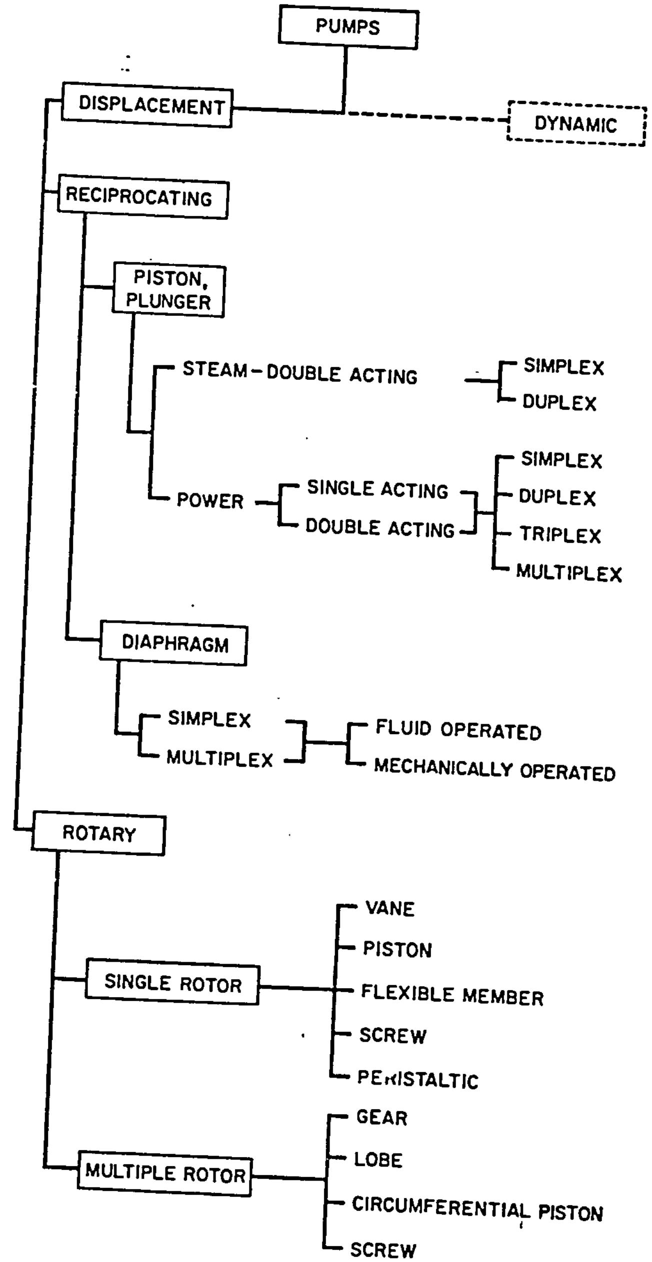
(Actually, cavitation effects would begin to degrade pump performance at a lesser Q, before P_a is reduced to zero.)

FIGURE 8-1

Classification of Pumps, (from Pumps Handbook, Karassik et al; McGraw-Hill, 1976.)



Classification of dynamic pumps.



Classification of displacement pumps.

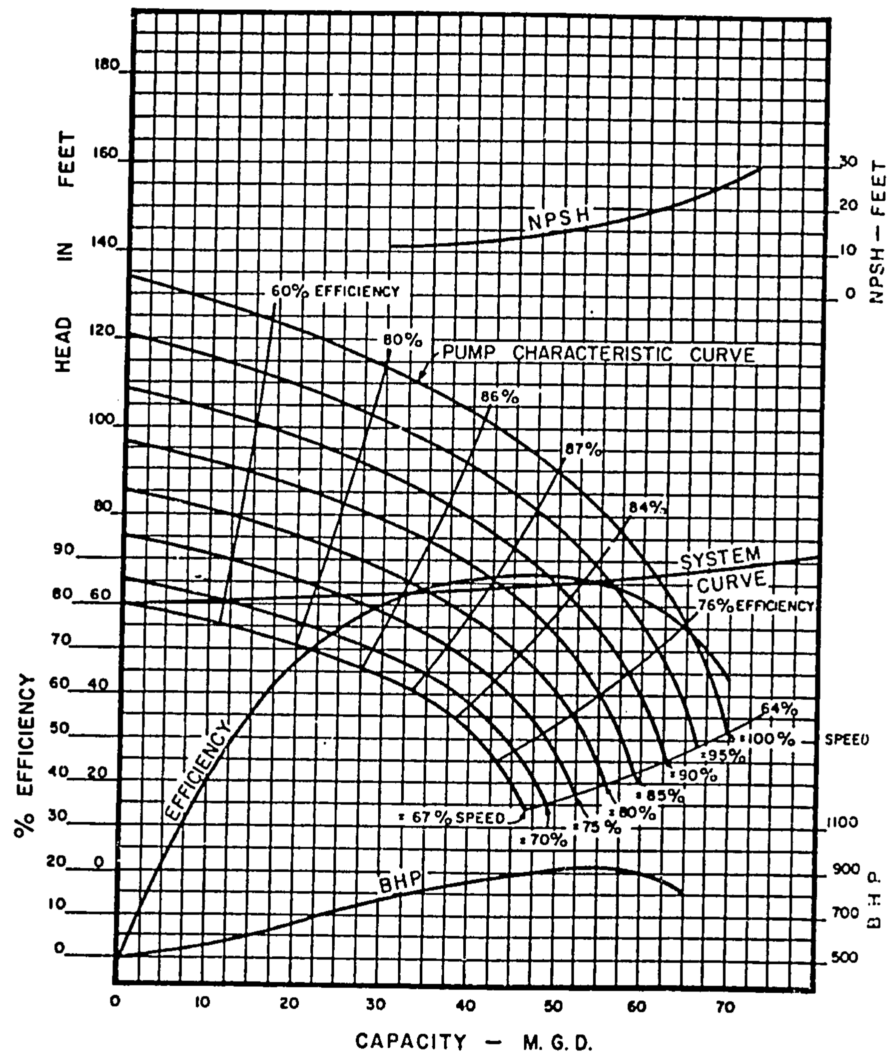


Fig. : System head curves for variable-speed operation for the Forney raw-water pump station in Dallas. (URS/Forrest and Cotton, Inc., Consulting Engineers)

FIGURE 8-2

From Pumps Handbook, Karassik et al., McGraw-Hill, 1976.

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: NOVEMBER 9

TIME: 2 HOURS

COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: 13. Design Strategy for Water Supply and Sewage Systems

SESSION OBJECTIVES:

To develop a practical outline (one that considers conditions in Egypt) of requested design steps ORDEV engineers should consider when designing water supply or sewage systems.

TECHNICAL COMPONENT: Process Simulation: ORDEV Engineers

SESSION: Design Strategy for Water Supply & Sewage Systems

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	1. At this stage of the simulation the participants alternate their player roles and complete the task outlined below: SETTING: ORDEV Office PLAYERS: 1 chief engineer 3 field engineers METHOD: Work in small groups Outline on flip chart Groups crosscheck outlines TASK: Prepare an outline describing the sequence of steps to take in designing a water supply/sewage system. The outline should include actual conditions and limitations in Egypt, such as: ° Types of equipment available ° Types of construction materials ° Types/Numbers of trained staff ° Contractor capabilities ° Power sources	

TECHNICAL COMPONENT: Process Simulation: ORDEV Engineers

SESSION: Design Strategy for Water Supply & Sewage Systems

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	PRODUCT: A practical outline to use in designing a water supply/sewage system.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 12

TIME: 1 Hr 20 Min

COMPONENT: Groundwater/Wastewater

SESSION: 14. Disposal of excess groundwater and wastewater.

SESSION OBJECTIVES:

To describe disposal alternatives for excess groundwater and wastewater.

To examine the advantages and disadvantages of various disposal alternatives.

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Disposal of excess groundwater and wastewater.

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
10 min	1. Ask participants to describe some of the ways they now dispose of excess groundwater. List these on flip chart Add other ways the group may have missed.	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	2. Divide them into small groups and ask them to identify and list on flip chart the advantages and disadvantages of these disposal methods. If there are alot of methods listed, you may want to divide up parts of the list among the small groups.	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
45 min	3. Let each of the groups report out and facilitate a discussion about the merits of these methods and which might be most suitable for use in their particular areas. The result of this discussion should be a list of recommended options for groundwater disposal.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 10

TIME: 2 Hrs. 15 Min.

COMPONENT: Maintenance

SESSION: 15. Introduction

SESSION OBJECTIVES:

The objective of the introductory session is to inform the students of the purpose of the maintenance workshop and of the techniques that will be used to conduct it.

The workshop goal will be to develop an equipment maintenance program suitable for facilities covered by BVS projects. A description of two local pumping stations will be included.

TECHNICAL COMPONENT: Maintenance

SESSION: Introduction

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
45 min	1. Purpose of maintenance workshop - Lecturette ° Develop equipment maintenance program for BVS ° Determine student's concept of maintenance solicit student's ideas on effective maintenance ° Establish method of equipment maintenance in Egypt	

TECHNICAL COMPONENT: Maintenance

SESSION: Introduction

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
45 min	2. Method of conducting workshop -- Lecturette o List and explain subsequent sessions - Flipchart o Describe WSSC system and maintenance programs - Flipchart o Discuss student participation: team approach team approach case study/simulation	1. - List of sessions

TECHNICAL COMPONENT: Maintenance

SESSION: Introduction

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	3. Description and History of Bladensburg and Hill Rd P.S. ° Dates place in service ° Types of equipment ° Role in WSSC distribution/collection system	2. Bulletin -- worm-gear installation for Bladensburg

TECHNICAL COMPONENT: Maintenance

SESSION: Introduction

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	4. Motor Maintenane Article - Handout ° Date published ° Key points of article - discussion ° Use flipchart to list key points as established by students	3. Article "Don't Damn the Motor"

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 10

TIME: 2 Hrs. 25 Min.

COMPONENT: Maintenance

SESSION: 16. Effective Equipment Maintenance

SESSION OBJECTIVES:

The objective of this session is:

- to establish concepts of effective maintenance
- to expand on student's maintenance experiences
- to define key terms used
- to discuss effects of good and poor maintenance

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
(25 min)	1. General definition - Establish from student's inputs Examples: ° Extend equipment life ° Increase reliability ° Minimize O&M costs Examples: Solicit from class ° Changing oil - PM ° Fraction HP motors - NO PM	Handout: 1. Article- Maintenance Management Systems

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	2. Types of Maintenance - Lecturette and Flip chart Solicit ideas from class on definition of ° PM - preventive maintenance - regular schedule of tasks ° CM - corrective maintenance ° breakdown maintenance Discussion - Proper level of maintenance ° Definition Have students develop and list definition on flip chart	

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. (continued) ° Vehicle analogy - changing oil too frequently vs. as required by manufacturer ° Checking impeller clearance: effect on pump flow and efficiency	

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	3. Experience of Egyptian Engineers - Lecturette ° Have each engineer describe in writing his maintenance experience by listing: * -- his maintenance responsibilities -- what he has done to promote good O&M -- condition of equipment in his area -- major maintenance problems in his area -- the views of his management of maintenance needs ° Use flip chart to list (summarize) results * NOTE: This should take 20 minutes to complete	

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	4. Effects of maintenance - Lecturette with team approach ° Have each team develop lists of positive effects of good maintenance and negative effects of poor maintenance ° Use team leader report to list on flip chart ° Handout - JKJ paper on MMS - Justification -- discuss concept of "Selling" maintenance	1. Article: Maintenance Management Systems Justification and Evaluation

TECHNICAL COMPONENT: Maintenance

SESSION: Effective Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	° Have each engineer indicate how BVS maintenance funds are used in his area List potential uses in flip chart -- vehicles, tools, test equipment, rehabilitation	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 13

TIME: 3 Hrs. 20 Min.

COMPONENT: Maintenance

SESSION: 17. Maintenance Management Programs

SESSION OBJECTIVES:

The purpose of this session is:

- to establish those elements which are an essential part of a good maintenance program.
- to explore how these elements can be used to manage the maintenance function.

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Management Programs

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Managing maintenance activities Lecturette o Solicit and list meaning of maintenance management -- Information needs -- Management support for field technicans a. comment on maintenance reports b. field trips	

136

TECHNICAL COMPONENT: MAINTENANCE

SESSION: MMP

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	2. Elements of maintenance program – Lecturette A. Word order Use flip chart to list student's ideas on fields required. Hand out examples from WSSC systems. Refine and expand original list on chart. Develop flow chart for C.M. work order Hand out WSSC and user's work order guide for manual system	1. Examples of work orders from WSSC manual and automated system

TECHNICAL COMPONENT: Maintenance

SESSION: MMP

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	B. Equipment inventory and identification system o Why inventory? solicit ideas from class reporting CM problems tracking equipment history scheduling PM spare parts	2. End user's guide

138

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Management Program

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	o Identification number Develop ID system for typical pumping station by Governorate Introduce Sri Lanka systems with handout	3. Equipment Identification Scheme S. DeSavan memo

139

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Management Program

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	C. Preventive Maintenance	
10 min	o Brief discussion of Preventive Maintenance as cornerstone of maintenance program	

140

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Management Program

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
(60 min)	D. Management reports ° Use flip chart to list types of useful reports as solicited from each team. Teams to be given 15 min to develop. ° Concept is "What do they want to know about maintenance as a manager?" (Write this question on flip chart) ° Use information listed to design report on CM ° Handout examples from WSSC manual and automated sytems	Sample management report on maintenance

141

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Management Program

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	E. Control of Maintenance Lecturette o Definition of systems control PM-CM-costs-manpower O Solicit reasons for need from class and list on flipchart o Review handout of JKJ report on systems control	<u>System Control</u> paper by J. Jordan

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 13

TIME: 1 Hr 20 Min

COMPONENT: Groundwater/Wastewater

SESSION: 18. Treatment of Water

SESSION OBJECTIVES:

To describe treatment alternatives for wastewaters.

143

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Treatment of Wastewater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
Two 40 Min Sessions	1. Review of Public Laws 48 and 93. a. Definition of fresh water and non-fresh water bodies b. Quality requirements for discharge to non-fresh water bodies.	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. Treatment alternatives a. Physical - bars, screens, comminution, sedimentation, skimming, etc. b. Biochemical -aerobic, anaerobic c. Chemical - chlorination, ozone, ultraviolet d. Others	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Treatment methods a. Vaults b. Septic tanks c. Imhoff tanks d. Oxidation ditches and ponds e. Sewage lagoons f. Trickling filters g. Activated sludge h. Others	Refer to "Water for the World," Tech Note No. SAN 2. M. Pg. 2, Figure 1 SAN 2.D.2 Pg. 3, Figure 2 SAN 2.D.3 HANDOUT HANDOUT SAN 2.D.5 HANDOUT SAN 2.D.6 HANDOUT SAN 2.D.7

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 14

TIME: 2 Hrs. 15 Min.

COMPONENT: Maintenance

SESSION: 19. Preventive Maintenance

SESSION OBJECTIVES:

The objective is to establish the parts of a PM pro [illegible] pply them to a facility that is typical to the Egyptian BVS project. The flow chart developed for Sri Lanka will be used and modified to fit an Egyptian model.

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	1. Determine sources of required PM tasks ° Solicit class input ° List: - O&M manuals - OEM's inquiry - Experience of field personnel	

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	1. (continued) handout typical O&M manual from Bladensburg SPS a. Installation b. Operation c. Maintenance give class 10 minutes to read manual	1. O&M Manual for DeLaval pumps

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
60 min	2. Maintenance Procedures ° What is a maintenance procedure? Discuss. ° Have each team prepare a procedure for a specified piece of equipment and present to class. Motor Control Center	2. Sample maintenance Procedures. WSSC and manufacturer literature

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. (Continued) Motor with slip rings Centrifugal pumps o Provide handouts from Hillsboro SPS and Potomac WFP. Use to discuss and list key elements of maintenance procedure -- Equipment name -- Cycle -- PM Tasks -- Location -- Number of Manhours -- Crew number -- Date -- PATS used	3. Proper Maintenance of Control article and Battery Maintenance article

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
(30 min)	3. Modify WSSC manual system to fit Egyptian systems. Distribute Sri Lanka PM flow chart and instruct teams to modify to fit their system. Handout JKJ article on manual PM systems.	4. Flow chart for NWS & DB of Sri Lanka 5. Article on non-automated PM system for WSSC Potomac WFP.

TECHNICAL COMPONENT: Maintenance

SESSION: Preventive Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
15 min	4. Who performs preventive maintenance on equipment - Lecturette o Discuss role of operators and maintenance technicians Teams to identify maintenance for pumping station Lists tasks of each for pumping station Lists to be made on flipchart of student's ideas	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov/14

TIME: 40 Min

COMPONENT: Groundwater/wastewater

SESSION: 20. Present a methodology for designing a simple sewerage network.

SESSION OBJECTIVES:

Present a methodology for designing a simple sewerage network.

104

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Design of Sewer Systems

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
Three 40 min sessions	THE FOLLOWING IS A LIST OF TOPICS WHICH WILL BE COVERED IN THIS SESSION: 1. Types of sewers: o House connection o Laterals or branches o Main sewers or secondary collectors o Trunk sewers or primary collectors o Interceptors.	

TECHNICAL COMPONENT: Groundwater/Wastewater

SESSION: Design of Sewer Systems

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. Sewer pipe materials: o cast iron o steel o concrete o ABS,etc.	

TECHNICAL COMPONENT: ______________________________

SESSION: ______________________________

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Appurtenances: o inspection boxes o distribution boxes o cleanouts o "Y"s o manholes o street gutters o grease traps, sand traps o automatic flush tanks o inverted siphons	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	4. Maps and plans Area map with building, streets, contours, canals and drains. As built plans of utilities, Example: water network electrical distribution	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	5. Estimation of wastewater flows - low, average and peak flows	
	6. Sewer network designs	
	7. Pumping station design	

TECHNICAL COMPONENT: G/W

SESSION:

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	8. Construction of sewerage system	
	9. Operation and maintenance of sewerage system	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 15

TIME: 1 hr 30 min

COMPONENT: Process Simulation: ORDEV Engineers

SESSION: 21. Preparation for Local Field Trip

SESSION OBJECTIVES:

1. To prepare for 1 day field trip to Bladensburg and Hill Road pump stations.

TECHNICAL COMPONENT: Process Simulation

SESSION: Preparation for Local Field Trip

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
5 min	1. Trainer relates what actions have occurred since the preparation of the design outline: o Water supply/sewerage system design completed o Water supply/sewerage system built and operating	

TECHNICAL COMPONENT: Process Simulation

SESSION: ______

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
1 Hr. 25 Min.	2. Prepare for field trip to Bladensburg and Hill Road pump stations: o Lecture on O&M planning o Prepare O&M data collection forms to use during field trips	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 15

TIME: 1 Day

COMPONENT: Maintenance

SESSION: 22. Field Trip to Pumping Stations

SESSION OBJECTIVES:

The purpose is to demonstrate to the class that proper maintenance will extend the life of a facility and its equipment for many years.

Examples of older sites and state-of-the-art pumping stations will be visited.

165

TECHNICAL COMPONENT: Maintenance

SESSION: Field trip to pumping stations

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	1. Describe session 6 exercise to students a. Two teams will be assigned to each station b. Each team will record list of major equipment of each station c. Teams will prepare maintenance program for their assigned station.	

163

TECHNICAL COMPONENT: Maintenance

SESSION: Field trip

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	2. Field trip to: a. Bladensburg sewage pumping station b. Hill Rd water pumping station c. Colesville water pumping station NOTE: The first two stations must be visited since they are part of session 6 exercises. The third station (Colesville) is optional.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov. 16

TIME: 5 Hrs. 45 Min.

COMPONENT: Maintenance

SESSION: 23. Prepare maintenance program for Bladensburg and Hill Road

SESSION OBJECTIVES:

The objective of this session is:

- to have each team prepare a PM program for one of two pumping stations visited the previous day.
- to identify problems and suggestion solutions for installing a similar program in their governorate.

167

TECHNICAL COMPONENT: Maintenance

SESSION: Prepare maintenance program for Blandensburg and Hill Rd.

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
15 Min	1. Review purpose of training exercise Use session 5 flip chart	

TECHNICAL COMPONENT: Maintenance

SESSION: Bladensburg and Hill Rd. project

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
180 Min.	2. Teams will prepare report covering: -- list of equipment to be included in PM program -- identification numbering systems for that equipment -- maintenance procedures including cycle times -- flow of information chart -- list of data they would expect to see from the previous month's maintenance work -- estimation of manhours and skills needed to complete work station PM -- establish their method of system control -- list of problems during assignment completion	

TECHNICAL COMPONENT: Maintenance

SESSION: Bladensburg and Hill Rd

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	3. Teams will also prepare separate reports on: a. list of problems establishing PM program in their Governorate b. proposed solution to each problem	

TECHNICAL COMPONENT: Maintenance

SESSION: Bladensburg and Hill Rd.

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
60 min	4. Presentation of results by teams -- Each will report on topic as noted -- List equipment including ID numbers to be included on flip chart (Teams A and C) -- Verbally, describe maintenance procedure for once piece of equipment (Teams A&C)	

TECHNICAL COMPONENT: Maintenance

SESSION: Prepare Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	4. (Continued) -- List data they need as maintenance managers on flip chart - Team B&D -- Verbally, report on number of manhours and labor skills needed for program - Team B&D instructor to compile list on flip chart -- List their methods of system control All teams to report verbally with instructor compiling list -- Verbally, report on problems completing assignmt	

TECHNICAL COMPONENT: Maintenance

SESSION: Prepare maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
60 min	5. Each team will list problems and proposed solutions in installing a maintenance program in their governorate. Instructor to compile list of problems and solutions.	

PM Program Report

1. List of equipment
2. Identification number
3. Maintenance procedures
   and cycle times
4. Flow of information chart
5. Management report data
6. Estimate of manhours and skill
7. Methods of system control
8. Problem list with assignment

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: NOVEMBER 16

TIME: 3 HOURS

COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: 24. Operation and Maintenance Planning

SESSION OBJECTIVES:

To write a practical O&M plan for two pump stations.

7-

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: Operation and Maintenance Planning

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	1. At this stage of the simulation, the participants alternate their player roles and complete the tasks outlined below: SETTING: ORDEV Office PLAYERS: 1 Chief Engineer 3 Field Engineers METHOD : Work in small groups TASK : Prepare an O&M plan for: ° Bladensburg Public Sanitation (Groups A&C) ° Hill Road Public Sanitation (Groups B&D) ° Present O&M plan to the other group working on different site plans PRODUCT: A practical O&M plan for two pump stations.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 19

TIME: 3 Hours

COMPONENT: Water Supply

SESSION: 25. Network Workshop

SESSION OBJECTIVES:

1. To practice doing the calculations and procedures of hydraulic network analysis.
2. To use a TRS-80 pocket computer to solve a hydraulic network analysis problem.
3. To observe a demonstration of how a micro-computer can be used to solve a hydraulic network analysis problem.

177

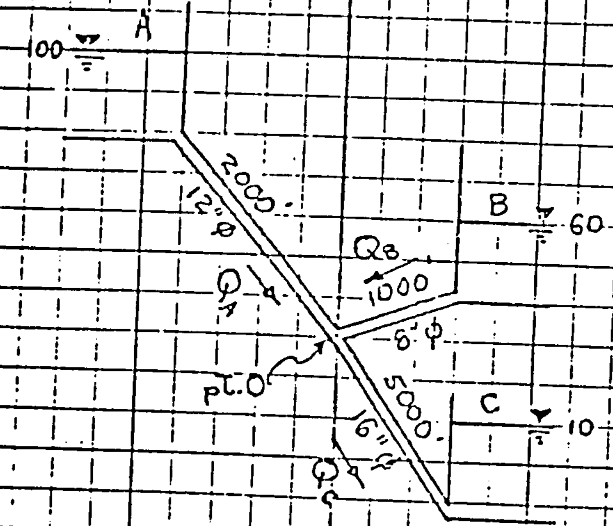
TECHNICAL COMPONENT: Water Supply

SESSION: Network Workshop

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	1. Present a sample network problem that will be worked out by hand.	
	2. Present a sample network problem that will be worked out by pocket computer.	TRS-80 Pocket Computer Model PC-4
	3. Present a sample network problem that will be worked out by microcomputer.	IBM-PC

12. Given: Three reservoir problem: El. A = 100', L_A = 2000', D_A = 12"; El. B = 60', L_B = 100[0'],
D_B = 8"; El. C = 10', L_c = 5000', D_c = 16". Hazen & William's C = 130

Find: Q_A, Q_B, Q_C, pressure elevation at junction



Assume flows as shown. ∴ $Q_A + Q_B = Q_C$

Heads must balance, ∴

$100 - h_{AO} = 60 - h_{BO}$; $60 - h_{BO} - h_{OC} = 10$

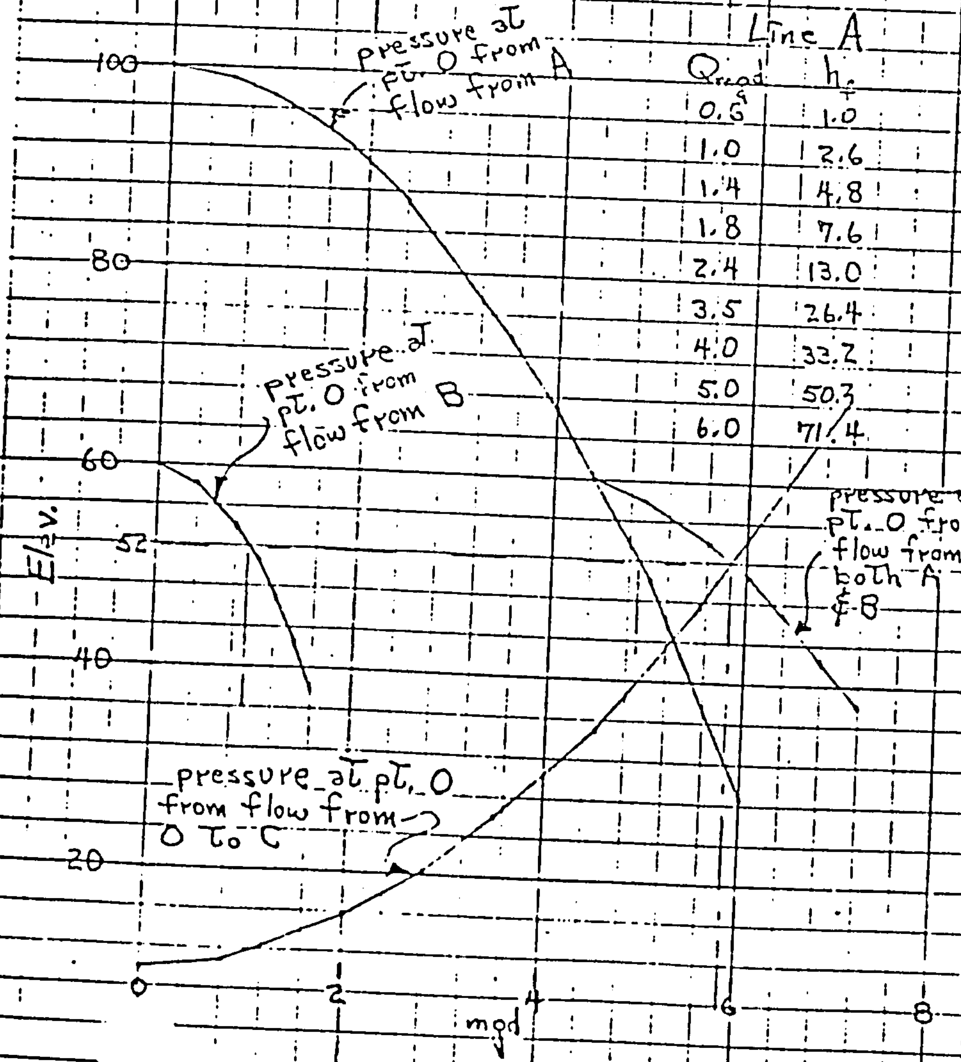
Solve graphically:

$h_f = K Q_{mgd}^{1.85}$ $\quad K = \frac{10.6\, L_{ft}}{C^{1.85} D_{ft}^{4.87}}$

$K_A = \frac{10.6(2000)}{(130)^{1.85}(1)^{4.87}} = 2.58$ $\quad K_B = \frac{10.6(1000)}{(130)^{1.85}(.67)^{4.87}} = 9.3$

$K_C = \frac{10.6(5000)}{(130)^{1.85}(1.33)^{4.87}} = 1.59$

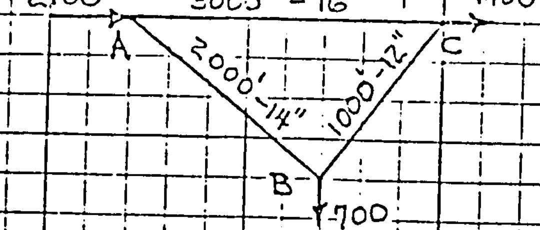
Line A Q_{mgd}	Line A h_f	Line B Q_{mgd}	Line B h_f	Line C Q_{mgd}	Line C h_f
0.6	1.0	0.4	1.7	0.8	1.1
1.0	2.6	0.8	6.1	1.2	2.2
1.4	4.8	1.0	9.3	2.0	5.8
1.8	7.6	1.2	13.0	2.8	10.3
2.4	13.0	1.4	17.3	3.5	16.1
3.5	26.4	1.6	22.0	4.5	26.0
4.0	32.2			5.5	37.5
5.0	50.3			7.0	56.5
6.0	71.4				



Ans:

Q_B = 0.9 mgd
Q_A = 4.9 mgd
Q_C = 5.8 mgd
pressure at O: 52

14. Given The level section of a city water distribution system and The flows in gallons per minute entering or leaving The pipe network at points A, B and C shown, find the amount and direction of flow in each pipe, disregard any differences in elevation of The pipes. Use Hazen-Williams C = 100



$Q_A = 2100$ gpm $= 3.03$ mgd — supply
$Q_C = 1400$ gpm $= 2.02$ mgd — Take-off
$Q_B = 700$ gpm 1.01 mgd — Take-off

$$K_{AC} = \frac{10.6(3000)}{(100)^{1.85}(1.33)^{4.87}} = 1.56$$

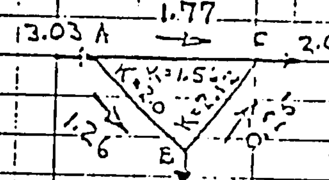
$$K_{AB} = \frac{10.6(2000)}{(100)^{1.85}(1.167)^{4.87}} = 2.00$$

$$K_{BC} = \frac{10.6(1000)}{(100)^{1.85}(1)^{4.87}} = 2.12$$

Solving by Hardy-Cross method:
1. Assume initial flows in pipes
2. Loop correction,

$$\Delta Q_p = \Sigma h_f / \Sigma |1.85 K Q_p^{0.85}|$$

ΔQ_p is in direction Tending To m[ake] heads along either path more nearly [equal]



	Q_p	h_f		$\Sigma\|1.85 K Q_p^{0.85}\|$
AC	1.77	$1.56\times(1.77)^{1.85}$	$= 4.53$	$1.56(1.77)^{0.85} = 2.54$
AB	1.26	$2.00\times(1.26)^{1.85}$	$= 3.06$	$2.00(1.26)^{0.85} = 2.43$
BC	0.25	$2.12\times(0.25)^{1.85}$	$= .16$	$2.12(0.25)^{0.85} = 0.65$
			$\Sigma h_f = 1.31$	$1.85\times 5.62 = 10$

$\Delta Q_p = 1.31/10.40 = 0.1264 \cong 0.13$

AC	1.64	$1.56(1.64)^{1.85}$	$= 3.90$	$1.56(1.64)^{0.85} = 2.38$
AB	1.39	$2.00(1.39)^{1.85}$	$= 3.68$	$2.00(1.39)^{0.85} = 2.65$
BC	0.38	$2.12(0.38)^{1.85}$	$= .35$	$2.12(0.38)^{0.85} = 0.93$
			0.13	$1.85\times 5.96 = 11.$

$\Delta Q_p = 0.13/11.02 = 0.0118 \cong 0.01$

AC	1.65
AB	1.38
BC	0.37

Discussion: First, assume a plausible distribution of flow that satisfies the inflow and outflow conditions. In general this trial distribution will not satisfy headloss conditions, e.g. h_{AC} will not equal $h_{AB} + h_{BC}$, which it must for the correct solution.

The trial solution will differ from the correct distribution by an amount equal to an imaginary circulation, ΔQ, around the loop. In each leg of the loop:

$$h_f = K Q^{1.85} \qquad (14-1)$$

The difference between the true headloss and the headloss associated with the trial flow is $h_{true} - h_{trial} = \Delta h_f$. Differentiate Eq. 14-1 to get ΔQ: $\Delta h_f = 1.85 K^{0.85} \Delta Q$. Over all legs in the loop: $\Sigma h_f = \Delta h_1 + \Delta h_2 + \Delta h_3 = 1.85[K_1 Q_1^{.85} + K_2 Q_2^{.85} + K_3 Q_3^{.85}]\Delta Q$.
The first trial's mismatch of headloss is Σh_f: i.e. $(h_{AC}) - (h_{AB} + h_{BC}) = \Sigma h_f$
Using trial Q_1, Q_2 and Q_3, solve for ΔQ.

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 19

TIME: 1 Hr. 40 Min.

COMPONENT: Maintenance

SESSION: 26. Budgeting for Equipment Maintenance

SESSION OBJECTIVES:

The purpose of this session is:

- to demonstrate a technique for developing a maintenance budget.
- to examine how information about key budget elements can control maintenance costs.
- to establish key budget elements.

(8)

TECHNICAL COMPONENT: Maintenance

SESSION: Budgeting for Equipment Maintenance

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Discuss recurring nature of O&M costs lecturette o Have teams list budget line items for maintenance for a typing pumping station o List these items on flip chart	

TECHNICAL COMPONENT: Maintenance

SESSION: Budgeting

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
(30 min)	2. Gathering cost information o Have teams report verbally on their method of determining costs. o Discussions of account numbers -- List components needed to identify expenditures a. facility b. type of expenditure c. group to be charged	

TECHNICAL COMPONENT: Maintenance

SESSION: Budgeting

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 min	3. Control of Maintenance Costs - Lecturette ° (Have teams list information they need to control costs. ° Discuss role of management reporting. ° List team ideas on flip chart on information needs Emphasize management role in process ° Handout and discuss WSSC monthly cost report	WSSC Monthly cost report

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 20

TIME: 2 Hours 25 Min

COMPONENT: Water Supply

SESSION: 27. Water Quality, Testing and Treatment

SESSION OBJECTIVES:

1. To identify current water quality criteria and to describe the overall quality of source water.
2. To examine the advantages and disadvantages of current water testing procedures.
3. To discuss the appropriateness of various treatment processes and treatment plant design.

TECHNICAL COMPONENT: Water Supply

SESSION: Water Quality, Testing and Treatment

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Determine what the participant's perceptions are about the quality of source water: TASK: o Meet in appropriate geographic groups o List the applicable water quality criteria you now use. (Have resource material available if necessary) o Using 3 of these criteria, describe the quality of source water from one/two of the following: -- Nile -- Canals -- Groundwater o Prepare to make short report to total group	

TECHNICAL COMPONENT: Water Supply

SESSION: Water Quality, Testing and Treatment

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	2. Reports to large group: o Trainer asks appropriate comparison type questions o If necessary, cite water quality criteria data from other sources: -- Egypt -- WHO -- USPHS,etc	

TECHNICAL COMPONENT: Water Supply

SESSION: Water Quality, Testing and Treatment

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	4. In order to determine current methods of testing and treatment, have them meet in geographical sub-groups. Let half of the sub-groups (assuming there are at least four) do the following: o Describe the testing methods most suitable to your situation, equipment, time, personnel. o List the advantages and disadvantages of each method used. Let the other sub-groups do the following: o List the treatment procedures currently being used o Make one suggestion for improving water treatment	

TECHNICAL COMPONENT: Water Supply

SESSION: Water Quality, Testing and Treatment

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
60 min	5. Lecture on Treatment Processes • Sedimentation: basic principle of sedimentation coagulation and flocculation. • Conventional sedimentation, and high-rate sedimentation. Sludge removal, treatment and disposal • Chemical aids to coagulation and flocculation • Importance of good sedimentation to good filter performance.	Linsley and Franzini CEPIS # 8 Degremont Handbook AWWA

TECHNICAL COMPONENT: Water Supply

SESSION: Water Quality, Testing and Treatment

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	• Deep coarse filters vs. small, fine-grain filters • Disinfection • Treatment for Fe, Mn removal • Filtration: removal of fine particles by absorption onto grains. Clean media, headloss; increasing headloss; breakthrough. • In design, select medium depth to balance headloss with quality. • Backwash assisted by air or jetting.	

190

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 20

TIME: 1 Hr. 30 Min.

COMPONENT: Maintenance

SESSION: 28. Maintenance Organization

SESSION OBJECTIVES:

The purpose of this session is:

- to establish the needs of the maintenance organization in terms of manpower and support services
- to prepare an organization chart that includes all types of personnel that are needed and their position in the organization

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Organization

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
40 minutes	1. Establish the maintenance organizations - Lecturette o Have teams prepare short report on maintenance organizations in BVS projects a. Show lines of authority b. Give 1-sentence description of role of each job classification shown on chart. c. Explain how they would have a failed motor repaired/replaced	

TECHNICAL COMPONENT: Maintenance

SESSION: Maintenance Organization

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	o Discuss and demonstration on flip chart typical maintenance organization o Compare maintenance organization with Egyptian model. Purpose is to emphasize need for maintenance to be distinct group.	

TECHNICAL COMPONENT: ______________________

SESSION: ______________________

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	2. Discuss job descriptions for field personnel Lecturette o Handout of WSSC job descriptions o Have teams list job duties for Egyptian electrician	Job descriptions

TECHNICAL COMPONENT: Maintenance

SESSION: (Maintenance Organizations)

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
20 min	3. Instruct teams to list support services needed for maintenance organization. Instructor to compile list on flip chart.	

195

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 21

TIME: 1 Hr. 40 Min.

COMPONENT: Maintenance

SESSION: 29. Hardware Needs

SESSION OBJECTIVES:

The objective of this session is:

- to establish the hardware needed to support a maintenance group.
- to prepare a plan for adequating outfitting for maintenance.
- to examine how maintenance is an organizational requirement that must be planned for in order to be successful

196

TECHNICAL COMPONENT: Maintenance

SESSION: Hardware Needs

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	1. Maintenance Hardware Needs - Lecturette o Have teams prepare lists of all possible parts of a corrective maintenance job. Example: Replacing a 50 HP motor with a new unit o List student's inputs on flip chart o Expand list as needed	

TECHNICAL COMPONENT: Maintenance

SESSION: Hardware Needs

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
30 min	2. Spare parts needs -- Lecturette o Discuss concept of inventory of enough spares to rebuild one unit Solicit from students their spare parts problems and list on flip chart Example: Long lead times	

TECHNICAL COMPONENT: Maintenance

SESSION: Hardware needs

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
(40 min)	3. Tools/test gear - Lecturette o Have teams prepare list of tools and test equipment available to their field personnel. o Compare lists submitted by teams and compile composite and expand if needed. o Distribute report on Sri Lanka tool/test gear needs and discuss.	Supplemental Sri Lanka report on outfitting a workshop

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Nov 21

TIME: 1 Hour 30 Min

COMPONENT: Water Supply

SESSION: 30. Groundwater

SESSION OBJECTIVES:

To review the basis of groundwater site selection, well installation and development, and the danger of contamination.

TECHNICAL COMPONENT: Water Supply

SESSION: Groundwater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
15 min	1. Ask the participants to state the extent to which groundwater is (or could be) a source of potable or commercially used water in each governorate (or a representative sample)	

TECHNICAL COMPONENT: Water Supply

SESSION: Groundwater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	2. Lecturette on the usual and unusual uses of well fields o As water supply o As ground water o As barrier to seawater intrusion o To lower high water table in Punjab	

TECHNICAL COMPONENT: Water Supply

SESSION: Groundwater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
	3. Lecturette on the selection of a well-field site	
25 min	test pumping well drilling installation development	

TECHNICAL COMPONENT: Water Supply

SESSION: Groundwater

TIME	ACTIVITIES (FULL DESCRIPTION OF EACH STEP IN SESSION)	RESOURCE/REFERENCE
25 min	4. Lecturette on the transport of contaminants towards production wells. Wastewater Gasoline Other chemicals	

204

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: Dec 3

TIME: 4 hours

COMPONENT: Process Simulation

SESSION: 32. Debrief Field Trip

SESSION OBJECTIVES:

To debrief field trip experience and prepare for last part of the course.

TECHNICAL COMPONENT: PROCESS SIMULATION

SESSION: Debrief Field Trip

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
30 min.	1. Review format for how field trip reports will be written and presented.	
2 hours	2. Participants work on preparing field trip reports.	
1 hour	3. Presentation of field trip reports to large group.	
30 min.	4. Review schedule and procedures for last week of course.	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: DECEMBER 3 - 4

TIME: 1½ DAYS

COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: 33. Program and Budget Planning

SESSION OBJECTIVES:

To develop a set of procedures ORDEV engineers can use in planning their public works program and budget.

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: Program and Budget Planning

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	1. At this stage of the simulation, the participants are assigned one of the following player roles and begin to work on the task outlines below: SETTING: ORDEV and Governorate Offices PLAYERS: Chief Engineer Field Engineers Representative from Governor's Office METHOD : Work in small groups and reports to large group.	

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: Program and Budget Planning

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	TASK: Develop a set of procedures to use in planning an annual (or 5-year governorate) level ORDEV public works program and budget. STEP 1 -- Prepare a specific strategy for starting an O&M program in your governorate STEP 2 -- Prepare a general set of procedures to plan the governorate public works program and budget	

BASIC VILLAGE SERVICE (BVS) TRAINING

TRAINER GUIDELINES

DATE: DECEMBER 5

TIME: 4 HOURS

COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: 34. -- Meeting Between ORDEV Engineers and Senior Governorate Managers

SESSION OBJECTIVES:

- To interact with senior governorate managers in a realistic situation.
- To develop a set of recommendations for facilitating the approval and implementation of BVS projects.

210

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: -- Meeting Between ORDEV Engineers and Senior Governorate Officials

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	This is the last part of the simulation. If scheduling permits, we want to hold a joint session with the senior governorate managers involved with the BVS program who are currently here for training. Therefore, the people involved in this session will be playing the following roles and will work on the task outlined below. Setting: ORDEV and Governorate Offices Players: ° Chief Engineers ° Senior Managers from Governorate Office Methods: ° Work in small groups ° Pairs of small groups interact	

TECHNICAL COMPONENT: PROCESS SIMULATION: ORDEV ENGINEERS

SESSION: -- Meeting Between ORDEV Engineers and Senior Governorate Officials (cont'd)

TIME	ACTIVITIES (Full Description of Each Step in Session)	RESOURCE/REFERENCE
	Task: ° Present plan developed in Session F. Program and Budget Planning to senior managers. ° Review interactions and discussion during presentation and identify ways to facilitate the approval of BVS projects. Product: ° Experience of meeting with senior managers in realistic situation. ° Set of recommendations for getting BVS projects through the system.	

9/2