Irrigation Training Manual: Planning, design, operation, and management of small-scale irrigation systems

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Preface and acknowledgments

In 1988 Agro Engineering conducted the small-scale irrigation training for both pre-service and in-service Volunteers working in irrigation development in Honduras. One of the major problems encountered during the training was the lack of appropriate reference materials applicable to small-scale irrigation development. There are numerous references available for irrigation, but most have been designed for developed country conditions or specific irrigation problems in developing countries. Thus the idea of producing a good training manual with an accompanying reference manual was born.

The content and scope of the project were discussed with Mr. Jaime Henriquez of OTAPS and Mr. Alfonso Barahona, the APCD who directed the irrigation training programs in Honduras. The outline and scope of work were reviewed and modified a number of times, and in September of 1991 Agro Engineering was asked to produce the manual.

Agro Engineering assembled a team of professionals with over 40 years combined experience in irrigation to write the manual. The authors have worked in over 20 countries in Asia, Africa, and Latin America with Peace Corps, CARE, USAID, universities, and several grassroots organizations. Together with Peace Corps personnel from OTAPS they further refined and amplified the outline.

The focus of the training manual was to be on Volunteers who do not have formal training in irrigation but who do have some math skills and knowledge of agriculture. Thus the Volunteers would be agronomists, agriculturists, engineers, and even business majors. The individuals who design and manage irrigation projects should all be able to use basic scientific calculators to add, subtract, multiply, divide, find square roots and averages. All of the authors have worked on projects where pipelines have failed, structures have been undersized and washed out, or other problems have developed because of a lack of basic irrigation knowledge on the part of the irrigationists. Thus the manual was developed to serve the needs of the agricultural Volunteers working with irrigation.

A word about the authors:

LeRoy Salazar is an agricultural engineer specializing in irrigation and drainage. He has lived and worked throughout Latin America and Asia and has almost twenty years of experience in his field. He has designed and implemented numerous irrigation training programs for the International Irrigation Center, USAID, Peace Corps, Utah State University, Colorado State University, Ohio State University, and various other private and public entities. He has written a number of training publications, including Water Management on Small Farms: A Training Manual for Farmers in Hill Areas and Irrigation Scheduling: A Training Manual for the International Irrigation Center.

Jim Tolisano is a watershed resource specialist with extensive experience in training with Peace Corps, CARE, USAID, and various other entities. He has developed a number of training publications.

Keith Crane is an agricultural engineer specializing in irrigation. He spent three years as a Peace Corps Volunteer working with irrigation in Honduras, then served an additional year in Bolivia. He designed and conducted the Hillside Agriculture course for Peace Corps in Honduras in 1991 and assisted in the training of irrigation Volunteers in 1988.

Lee Wheeler is an agricultural engineer. He has served in the West Indies in Peace Corps working with both irrigation and conservation. He was an irrigation engineer with the Soil Conservation Service. His 14 years of experience in irrigation also include irrigation development work in Guatemala and Honduras. He has designed and conducted a number of irrigation training programs for such entities as the International Irrigation Center and the Peace Corps.

David Radtke is an agronomist who worked as a Peace Corps Volunteer in Guatemala for five years. During this time he designed several small-scale irrigation systems. He has 8 years experience as an irrigation agronomist.

Maya ter Kuile is an agronomist who has worked and lived in several Latin American countries including Guatemala, El Salvador, Costa Rica, Honduras, The Dominican Republic, and Mexico. She has conducted a number of training programs with the International Irrigation Center. She trained Peace Corps Volunteers in irrigation agronomy during 1988.

Other Acknowledgments:

The authors wish to thank a number of other people who provided valuable input to the manual:

-Special thanks go to Mr. Gaylord Skogerboe, Director of the International Irrigation Center who provided valuable assistance on the content and format for the manual.

-Ms. Amy Benner, another Returned Peace Corps agricultural Volunteer working with Agro Engineering. Her input and assistance in bringing the manual to its final form is greatly appreciated.

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-Mr. Jaime Henriquez, who saw the value of the project and was able to prioritize the work before he left Peace Corps.

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-Numerous reviewers, professors, and consultants who provided valuable constructive comments and materials.

Introduction to the irrigation manual

Purpose of this manual

The Irrigation Manual is designed to serve as a reference resource for trainers involved in irrigated agriculture training for Peace Corps. The Irrigation Manual consists of two parts: (1) the Irrigation Training Manual, and (2) the Irrigation Reference Manual. Individual sections of the manual can be used to supplement a wide variety of technical training programs, or the entire manual can be implemented as a specific irrigation training course. The complete training course should fully prepare Volunteers who will serve as irrigation specialists to plan, implement, evaluate, and manage small-scale irrigation projects in arid, semi-arid, or sub-humid tropical and subtropical climates. The manual is also designed to serve as a technical reference for trainers, Volunteers, or other professionals who may be seeking solutions to specific irrigation questions or problems.

The manual is designed to support trainers carrying out pre-service or in-service training courses for Peace Corps Volunteers who will apply irrigation practices in some part of their work service. The manual is also designed to provide continued support to Volunteers during the course of their service through the technical reference sections. The technical reference will replace several manuals that Volunteers who work in irrigation commonly use. In addition, the technical reference sections focus on small-scale projects, in contrast to most other irrigation references that are available. The manual is structured to cover the following materials:

The training sessions

Session plans are included to provide a comprehensive background in irrigation principles and practices. Each session plan includes the goals and objectives for the session, an overview of the purpose of the session, a description of activities which can be performed to fulfill the objectives, a list of tools and materials required, and location of additional technical information in the Irrigation Reference Manual. The session plans are grouped in the manual according to topic areas. The session groupings do not necessarily reflect the order in which the sessions should be presented in a training. It is assumed that the training staff will prepare a session schedule that is unique to each training and that reflects collaboration with other Peace Corps training needs, such as language and availability of work sites.

Section 1 Introduction to Irrigation Principles and Practices

The Role and Purpose of Irrigation
Assessing Trainee Math Skills
Tool Use and Safety

These introductory sessions are intended to enable Trainees to understand the need for irrigation in tropical dry and sub-humid ecosystems and to define their own objectives for the training and beyond.

Section 2 Community Organization and Mobilization

Conducting a Community Needs Assessment
Community Organization and Mobilization
Communication Techniques
Problem Solving
Working with a Community Water Users Association
Construction of Projects in a Community

These sessions provide Trainees with opportunities to develop and test skills in working with small groups in rural communities to define problems, identify solutions, and develop and implement projects.

Section 3 Inventorying the Physical and Biological Resource Base

Watershed Hydrology
Water Flow Measurements
Surveying and Field Measurements
Soil -Plant -Water Relationships
Conducting Environmental Assessments

Trainees must acquire skills enabling them to evaluate and monitor soil, water, and ecological attributes of the areas in which irrigation projects will be developed. These sessions provide learning exercises enabling Trainees to identify and quantify water sources, conduct measurements of field and watershed conditions, analyze physical and chemical soil properties, and identify environmental concerns to make certain that irrigation projects are carried out in a manner that sustains ecological processes.

Section 4 Developing Water Sources

Diversion Dams
Designing Spring Boxes
Selecting Pumps
Design and Use of Pumps
Installing, Operating and Developing Maintenance Plans for
Pumps
Wells: Hand Dug and Drilled
Storage Pond Design, Construction, and Management

Trainees learn hands on techniques that will enable them to capture and divert water from springs, seeps, or streams; dig, drill or rehabilitate shallow wells; use and repair hand and power-driven pumps; and build and maintain small ponds for storing water supplies.

Section 5 Assessing Irrigation Water Requirements

Estimating Net Crop Water Needs
Estimating the Efficiency of Irrigation Systems
Estimating Gross Daily Irrigation Requirements and Design Capacity

These sessions provide Trainees with opportunities to estimate the amount of water available and required to sustain an irrigation system. Trainees will also acquire managerial skills enabling them to evaluate the most efficient irrigation designs that can make the best use of available soil and water resources.

Section 6 Farm Water Delivery Systems

Components of Farm Irrigation Systems

Canal Design, Construction, and Maintenance
Control Structures: Checks, Diversions, and Drops
Pipe System Design, Construction, and Maintenance
Land Leveling or Smoothing
Surface Irrigation Systems
Sprinkler Systems
Trickle or Drip Systems

In these sessions Trainees learn the basic skills necessary to design and construct small irrigation systems using gravity, sprinklers, or drip methods to deliver water. Sessions also require Trainees to work in the field constructing and rehabilitating actual operating systems.

Section 7 Farm Water Management

Basic Concepts in Farm Water Management
Basic Soil and Water Conservation Practices
Developing Irrigation Schedules
Evaluation, Operation, and Maintenance

Sustainable use of irrigation systems requires precise management of soil and water resources. Trainees will construct soil conservation measures to minimize soil loss and promote high nutrient content in soils. They will also conduct evaluations and prepare water application schedules and operation and maintenance plans for existing irrigation systems.

Section 8 Waterlogging and Salinity

Basic Concepts of Waterlogging and Salinity
Control of Drainage and Salinity Problems

Trainees will work in the field constructing measures to minimize or avoid problems with waterlogging or high salt content in soils. Sessions will also provide the conceptual background to enable Trainees to anticipate problems and solutions in a variety of physical and social settings.

Section 9 Project Planning and Development

Conducting Economic Analyses
Proposal Writing

Trainees will acquire the technical skills to determine if projects are financially or economically feasible, learn how to develop project budgets and procurement plans, and write proposals to solicit financial support.

The amount of actual technical training time required to complete all 40 training sessions is estimated to be between 147-172 hours. The discrepancy in estimated time requirements is due to the fact that some training sites may have immediate access to field practice sites while others must factor in travel time. Also, the skill levels of Trainees will influence the amount of time needed to complete each session.

Time requirements by training topic section are estimated as follows:

Section	
1 Introduction to Irrigation Principles and Practices	3 Hours
2 Community Organization and Mobilization	12 Hours
3 Inventorying the Physical and Biological Resource Base	12 Hours
4 Developing Water Sources	32-37 Hours
5 Assessing Irrigation Water Requirements	5 Hours
6 Farm Water Delivery Systems	54-74 Hours
7 Farm Water Management	13 Hours
8 Waterlogging and Salinity	10 Hours
9 Project Planning and Development	6 Hours

TOTAL	147-172 Hours

Assuming that a minimum of six hours per day can be dedicated to technical training activities, and that training can proceed for a minimum of 5.5 days per week, then approximately five weeks will be required to complete the training.

In-service trainings will likely be constrained by time limitations, which will require trainers to pick and choose among specific topic areas and field activities that will meet Volunteer defined needs.

The irrigation reference manual

This companion manual to the Irrigation Training Manual provides detailed technical information to support the topics covered in the training sessions. This technical reference material is intended to provide trainers with sufficient background information to prepare for each training session. In some cases, the reference sections include prepared materials that trainers can simply photocopy and distribute to complete some sessions. The environmental assessment exercise is an example of these prepared materials. In addition to providing a comprehensive background in the basic technical skills necessary to plan, prepare, construct, manage, and evaluate irrigation systems, the manual also emphasizes skills to ensure that irrigation practices will respect broader ecological and social concerns.

The technical reference materials should be distributed or photocopied and distributed to Trainees for use during their Volunteer service. The collected materials in the reference section can adequately serve as a comprehensive technical manual on irrigation practices and water resource management covering most problems that Volunteers are likely to encounter.

The reference section concludes with an annotated bibliography of related texts and publications that trainers and Volunteers may also want to reference for technical support.

Overview of the training sessions

While short-term, intensive training in irrigation principles and practices cannot be expected to produce professional irrigation specialists, it can provide Volunteers with sufficient background and confidence to serve well as irrigation technicians. After completing the activities included in the training sessions, Volunteers should be capable of confronting and successfully solving a wide variety of problems related to the application of irrigation practices. They should also be fully aware of the complexity of applying and managing irrigation systems and be prepared to continue their learning efforts throughout their Peace Corps service.

Irrigation principles and practices

Irrigation systems are primarily used to supplement the water requirements of growing plants, which sounds like a simple enough task on first consideration. Accomplishing this task in a manner that is socially and environmentally sound, however, requires skills that bring together information and experience from a wide variety of technical fields, including hydrology, soil science, hydraulics, agronomy, plant science, watershed management, engineering, and economics.

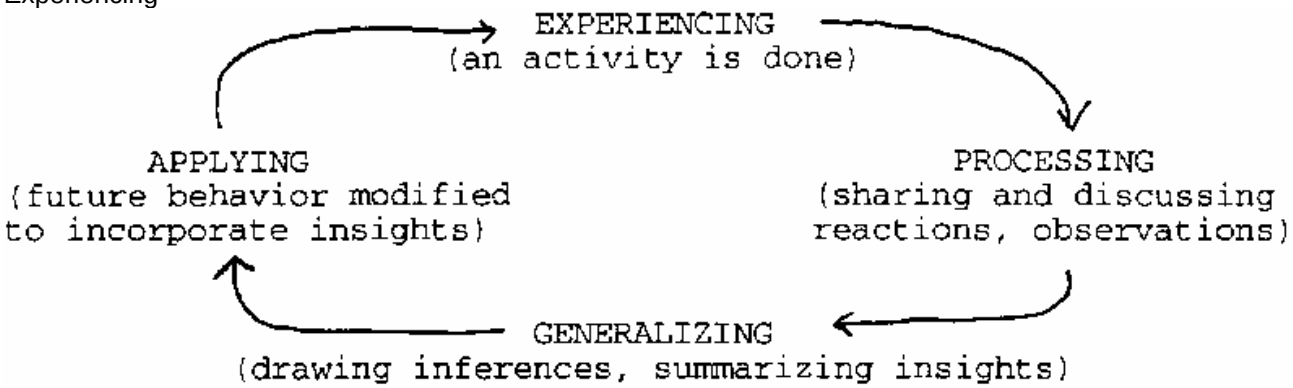
Peace Corps Volunteers working with irrigation practices as part of their service may encounter many diverse problems and situations that will require them to apply techniques or concepts that cut across these various technical disciplines. This training manual is designed to provide these Volunteers with enough interdisciplinary skills to address diverse problems and situations. Volunteers who complete the training may not know precise answers to all the irrigation problems they will encounter. They should know enough, however, to identify the information they need to solve a problem and where or how to find it.

The experiential learning approach

Irrigation is a very practical art and science. It requires skills that are grounded in field experience. As a result, the training sessions in this manual largely emphasize exercises that require Trainees to participate in hands-on work assignments. The overall curriculum consists of approximately 70 percent field sessions and 30 percent classroom sessions. Even in the classroom sessions, however, Trainees are expected to play a strong participatory role and complete assignments that require self-motivation, communication skills, and cooperative problem solving. Each Trainee will have a participatory, leadership, or independent role to fulfill in designing, constructing, or rehabilitating various components of an actual irrigation system in the field. This physical work forms the foundation of the experiential learning methodology emphasized throughout the training sessions.

Experiential learning is exactly what the name implies people learning by doing. Experiential learning occurs when a person engages in an activity, reviews this activity critically, identifies useful information from this analysis, and then applies the results of the process in subsequent practical situations. The experiential process follows the following theoretical circle:

Experiencing



Experiencing: Each training session should include one or more activities that the Trainees will do. Requiring Trainees to experience the content of sessions will increase their opportunity for becoming aware of how they currently handle related situations and skill areas that they need to develop or strengthen. Trainers must be careful to avoid putting Trainees in situations in which the skills being tested cannot be accomplished given the entry skill level of the group. Experiences can be developed in classroom settings, using role plays, games, small group discussions, case studies, videos or slides, sharing of personal experiences, or training of Trainees by one another.

Processing: The Trainees must follow each activity by immediately analyzing the experience. It is very helpful for the trainer to provide some guidance questions for Trainees to answer, such as: "How did time management become a problem in completing the pump repair?" "What went wrong in this role play?" "What else could you have done?" With carefully worded questions such as these, Trainees can do an effective analysis with minimal interference from the trainers.

During this processing phase, individuals share with others the specific experiences they had during the activity. This can be done through group discussions, written reports, generating and analyzing data, one on one dialogues, or interviews. Individuals share both their cognitive and emotional reactions to the activities in which they were engaged and then try to link these thoughts and feelings together to derive some meaning from the experience. Putting their responses into language is the critical link in enabling Trainees to develop generalizations that they can then apply to new situations in the future.

Generalizing: As a conclusion to this analysis process, Trainees need to individually or collectively draw generalizations or inferences. A generalization is a rule or concept, based on facts, that a person can accept and act on. An inference is a generalization that a person can accept tentatively but which needs to be tested before the person is willing to incorporate it into his or her behavior. An example might be the following:

In conducting interviews of government officials, the Trainee group may draw as a generalization or inference that better information can be obtained when open-ended questions are asked rather than when leading questions are asked.

Activities that can facilitate this generalizing process include:

- summarizing the generalizations or inferences into concise statements or concepts,

- establishing agreement on definitions, concepts, key terms, and statements, and

- relating the activity and generalizations or inferences to past experiences, thoughts or feelings.

These activities can be done individually or in a group setting.

Applying: After generalizations or inferences have been drawn, Trainees need opportunities to practice using these generalizations or to further test their inferences. These practice or trial efforts should be directly related to the work the Trainees will be doing after they complete the training. For example, if Trainees have acquired basic generalizations or inferences about how to plan small surface irrigation systems, they now need an opportunity to work with a small system. Useful techniques and activities to facilitate this process include having Trainees develop plans of action, personal goals, and strategies for modifying personal behavior.

The trainer's role in experiential learning

The primary responsibility of the trainer is to provide the Trainees with an effective and appropriate learning environment and to facilitate an active process by which Trainees determine and act on their individual learning needs. This can be best accomplished by trainers who:

- encourage the active involvement of all Trainees,

- promote an atmosphere of cooperation and open dialogue,

- enable Trainees to work at a pace and skill development level most appropriate to their own capabilities and ambitions,

- assist Trainees in identifying the linkages between each training session,

- provide Trainees with opportunities and incentives to constantly relate training experiences to "real life" situations,

- guide Trainees toward materials and people that may expand their learning experiences, and

- make themselves available to serve as resources without establishing themselves as all-knowing experts who merely dispense answers.

Timing, location, and trainee preparedness

The training sessions have been designed to support Trainees who have already had some training in language and cross-cultural skills. It is assumed that the Trainees will have already completed a basic Peace Corps Pre-Service Training (PST) before beginning the Irrigation Principles and Practices skills training.

Developing irrigation skills to apply as a Peace Corps Volunteer in developing country situations is not strictly a technical exercise. The "irrigation" that Volunteers will practice is a very obvious blend of cross-cultural communication skills and technical concepts involving water, soils, and plant science. The session plans in this training manual reflect this fact. The training sessions have been designed so that technical concepts are presented and acquired through cross-cultural experience. The benefits and skills development that Trainees will experience from the irrigation training will be dramatically enhanced if they have had, at a

minimum, sufficient language training to allow them to take on very basic communication tasks with farmers and in a market.

If Trainees have not participated in a PST or had some language skills development, then it is recommended that the training be done in a stateside (U.S.) location where Trainees will have access to rural or cross-cultural experiences. In-country training locations should include access to farm and market conditions typical of most Volunteer assignments. Trainers should review the list of work sites required to fulfill the training sessions, and then identify a suitable training location that will provide reasonably quick access to a host of sites that meet these needs. Reducing the travel time from the classroom to potential work sites provides the Trainees with more opportunity to complete their tasks without panic. Given the tremendous time constraint that is already built into the training, this quick field access becomes very important.

Trainees should be prepared to work long hours with minimal supervision. While irrigation field work can require a great deal of physical exertion, any reasonably healthy person can perform the tasks required. Irrigation training should be accessible to any man or woman who can wield a shovel or connect a pipe. It is recommended, however, that potential Trainees be screened to indicate any previous experience or capabilities working with basic math. Irrigation system designs or repairs frequently involve the use of skills in algebra, geometry, trigonometry, and statistics. Trainees who have not had some exposure to these concepts in the past, or who do not feel they will be capable of bringing these skills up to speed quickly, may find the training a bit overwhelming at times.

Implementing the irrigation training sessions

Conducting a pre-service or in-service training in irrigation principles and practices will involve the following steps:

1. Establish host country and Peace Corps program goals and objectives.

2. Conduct a staff development workshop that enables staff to define roles and responsibilities.

3. Prepare a schedule of training sessions and activities.

4. Identify suitable work sites for conducting all field activities.

5. Assemble written materials, visual aids, and supplies.

6. Prepare the work sites.

<u>Establish Program Goals and Objectives:</u>

The training staff need to work with the in-country Peace Corps program officers to define the entry level skills that are expected of irrigation Volunteers. These skill levels will greatly influence the level of detail and material content in many training sessions.

Trainers also need basic information about country agricultural and irrigation practices. This will enable the training sessions to be modified so that the information is site specific and not generic. Specific information that should be obtained includes:

- climatic data,

- typical crops cultivated and total crop acreage,

- typical farm sizes and approximate yields by crop for various farm size classes,

- crop planting seasons,

- types of irrigation systems in use and acreage irrigated,

- types of farm equipment typically used by small or medium sized farms (e.g., pumps, generators, tractors),

- soil conservation practices in accepted use by farmers, and

- components of in-country extension systems.

Ideally, the technical trainers will have time to meet with government or private sector officials working with small and medium-scale irrigation programs in country and to visit actual irrigation systems and interview farmers. Trainers should allocate at least one week, depending upon the size of the country, diversity of systems in use, and ease of travel, to interview officials and farmers and visit as many different farms as possible.

If interviews and field trips will not be possible, then the trainers should have the Associate Peace Corps Director (APCD) bring together current or recent in-country irrigation Volunteers for a group meeting. These Volunteers, along with the APCD, can help orient the trainers as quickly as possible. Trainers must remember, however, that the experiences and skill levels of these Volunteers may be limited and may not provide the trainers with all the background information they may want.

Conduct a Staff Development Workshop:

The work load during the training will, at times, seem to be increasing exponentially on a daily basis. The best way for the training staff to maintain some sense of efficiency through all of this is for the staff members to mutually define each person's role and responsibilities. Some people will have limited training experience and will benefit from some introductory training-of-trainers sessions. The APCD facilitating the trainer should work with the Training Director to prepare a minimum of a three-day Staff Development Workshop. This workshop should include sessions that:

- allow the trainers to learn about each other's backgrounds, strengths, weaknesses, and specific areas of interest;

- develop experiential learning skills and get trainers to build experiential learning practices into the sessions they will be conducting;

- build communication skills and result in some agreed upon mechanisms for working out problems, disagreements, or misunderstandings that may arise among the staff during the training;

- enable the staff to plan a daily schedule for the entire training and define the roles that each member of the training will fulfill every day in the schedule; and

- enable the staff to prepare materials and organize for the training. Technical staff will be able to use this time to modify and assemble materials for each lesson plan and make the necessary contacts for work sites to be used by Trainees.

If language training will be incorporated into the technical training, then the technical trainers should work with the language trainers to enable them to build technical terms and concepts into their language lesson plans.

Prepare a Schedule of Sessions and Activities:

The design of the training should always be location specific and influenced by the types of Peace Corps programs being implemented, host country program objectives, and actual site conditions. These factors will determine the sequence of training sessions, priority of session topics to be covered, level of detail needed in each session, and entry level skills that should result from the training. A schedule of sessions and activities for a training should be an output of the Staff Development Workshop. In developing this schedule, the staff should consider the following:

- host country program goals, farming practices, typical skill levels for sites in which Volunteers will be working;

- number of Trainees and trainers involved;

- physical, ecological, and social conditions in the countries for which training is being carried out;

- apparent skill levels of the Trainees (if known);

- total number of hours available for each training component: technical, cross-cultural, generic Peace Corps program sessions, and language (remember, too, to factor in "slack time" to account for breaks between sessions and travel time to and from work sites, for example);

- length of training and its relationship to the tasks that will be attempted in Trainee field projects;

- training site conditions; and

- topics and level of detail covered in other Peace Corps trainings in which Trainees may also participate.

With this information in mind, the staff can proceed through the following steps:

1. Prioritize the skills that must be emphasized in the training and define the level of detail required for each.

2. Draw up a list of sessions to be carried out along with their approximate time requirements. Aim for a training schedule that will have about 65-75% in-the-field activities and 25-35% classroom sessions. Be critical about what must be included in the training and what is optional. Overloading Trainees with information will not yield good results. Determine with some level of precision how much time will be required for Trainees to complete field projects, including after-session repair and maintenance work.

3. Map out a list of sessions to be covered during each week of the training. The daily schedule can be built from this initial rough outline. In mapping each week, consider (a) the field tasks that must be done first and which can be plugged into the training on an as-fits basis, (b) the total amount of time and probable training periods that will need to be devoted to field project maintenance and repair, (c) weekly themes to be emphasized, (d) ways to link classroom activities directly to field work so that they reinforce one another, and (e) a pace that can be upheld by both the training staff and the Trainees. Training staff should also be prepared to limit the amount of material covered in the first few days, since Trainees will need this period to orient themselves and develop necessary work attitudes.

Identify Suitable Work Sites:

An irrigation training will require a great deal of practical, hands-on field experience, mostly to give Trainees an opportunity to learn directly their own skill levels. The field activities that are likely to be carried out in a typical irrigation training would include the following:

- Collecting baseline data about a representative community's needs and problems related to irrigation and water resources.

- Meeting with representatives from a community water users association.

- Delineating a small watershed and assessing watershed conditions in terms of soil and water resources.

- Measuring flow rates in small channels.

- Calculating the slope and total area from a water source to a potential irrigated field site.

- Evaluating the movement of water and plant growth characteristics in several different soil types.

- Constructing earthen or rock dams to divert water from small channels.

- Developing the flow from a spring as a water supply and evaluating completed spring boxes.

- Rehabilitating an existing well and evaluating work in progress on a hand dug and drilled well.

- Evaluating a variety of pumps used to lift water and repairing a simple pump.

- Constructing a small pond to store water for field irrigation.

- Evaluating the soils and irrigation practices being used on a farm to grow crops.

- Constructing irrigation canals to transport water to a field.

- Installing pipe-works to convey water from a source to a field.

- Smoothing the ground surface in a small field.

- Installing sprinklers to apply water in a field.

- Installing perforated pipe to apply water through a drip fashion in a field.

- Constructing a terrace, planning a contour row of crops, and constructing check dams in a gully.

- Evaluating soils that have been subject to waterlogging or high salt content and applying amendments or procedures to reduce the damage to these soils.

Trainers need to have identified suitable sites to complete all of these activities. Contact should have been made with local farmers to inform them of the purpose and duration of the training and solicit their participation and support. Again, it is most advisable to locate a physical training site that provides close access to field conditions that will fulfill all of these training needs.

Assemble Materials Aids and Supplies:

Trainers should have all handouts, visual aids, and other teaching tools completed and organized before the training begins. The session plans include reference to materials in the appendices or other texts that can be photocopied directly or modified and typed to serve as handouts, tests, or exercises for the Trainees. Each session plan includes a list of materials that will be needed to complete the activities included. The session plans also describe video support that can supplement each topic.

It will be essential for the trainers to build a strong reference library available to the Trainees throughout the training. The bibliography in the technical reference component of this manual includes an annotated list of books and documents many of which should be available at any training site. Most of these materials should be available through the Peace Corps Information Collection and Exchange (ICE) service.

Trainers must also assemble a complete set of tools to enable Trainees to complete their field projects. Every Trainee must be provided with tools that they are to keep throughout their service. Tools and equipment (indicated in Appendix A of the Irrigation Reference Manual) must be at the training site and made available on a loan basis to Trainees throughout the duration of the training.

Training session

Section 1: Introduction to irrigation principles and practices

*** The Role and Purpose of Irrigation**
*** Assessing Trainee Math Skills**
*** Tool Use and Safety**
*** Exam: Section 1 (Math Skills Assessment)**

Session Topic: The Role and Purpose of Irrigation

Session Goal: To enable Trainees to identify the need for irrigation and to describe their own training goals and expectations.

Session Objectives:

(1) Trainees will be able to define irrigation and describe the benefits of irrigation in the production of food and fiber.

(2) Trainees will be able to describe how irrigation is practiced in varying topographic, climatic, or social conditions.

(3) Trainees will identify their own expectations, goals, and objectives for the training.

Overview: This session should serve as the introduction to the training. Volunteers are provided with an overview of the purpose and means for applying irrigation practices in a variety of conditions. This session should be used by trainers to describe and show visually what irrigation is, what its benefits are, and the basic concepts that must be understood in order to do an irrigation project correctly. Trainees should also write down some of their own expectations, goals, and objectives for their service.

Session Activities:	
Time	
30 Min.	Trainer has each person in the room select a partner.
	The partners pair off and obtain some basic background information about each other. Specifically, each person should take turns asking their partner:
	- area they are from in the U.S.,
	- general work experience, educational training, and personal interests that might relate to the work they anticipate doing as a Peace Corps Volunteer,
	- background experience they may have in agriculture or irrigation,
	- motivation for joining Peace Corps, and
	- goals and expectations they have for the training.
20 Min.	The group will reconvene as a whole. Each person introduces his or her partner to the group and provides a brief summary of the partner's background and training goals and expectations. Trainer records goals and objectives on a flip chart, without reference to the individual person who has voiced them.
10 Min.	Trainer presents a simple and concise description of the role and purpose of small-scale irrigation in tropical agriculture. Trainer can show video from International Irrigation Center Module No. 1, which presents these concepts graphically.
15 Min.	Trainer concludes session by going over the training schedule in detail, referring back to the Trainees stated goals and objectives frequently and showing how the training sessions will attempt to meet them.

Trainer Notes: Time allotments for this session will depend upon the number of Trainees in the group.

Materials Required:

* flip chart
* notebooks for Trainees
* video cassette player

Selected References:

Chapter 1, Irrigation Reference Manual International Irrigation Center Module #1

Session Topic: Assessing Trainee Math Skills

Session Goal: To determine the specific mathematical skills that Trainees will need to acquire or improve to work in irrigation.

Session Objectives:

(1) Trainees will complete a self-directed test of mathematical skills.

(2) Trainees will prepare a list of mathematical skills they intend to develop more fully or improve during the training program.

Overview: Volunteers who will be working with irrigation principles and practices must have the capacity to work confidently with basic algebra, geometry, and trigonometry. Many Trainees will have had limited mathematical training or will not have used math formulas for many years. This session, preferably presented at the beginning of the training, offers trainers and Trainees an opportunity to identify specific mathematical skills that Trainees will want to strengthen in order to increase their comprehension throughout the training.

Session Activities:	
Time	
10 Min.	The trainer should distribute prepared handouts that include a comprehensive set of mathematical problems to be solved. The problem set should include numerous examples of the kinds of problems Volunteers can be expected to encounter in the field, and the problems should reflect appropriate characteristics of local conditions. The trainer will review the test questions with Trainees as a group and make conversion tables, calculators, and area/volume table available.
30 Min.	Trainees will work independently to answer each question on the handout.
20 Min.	The trainer will go through the problem set with the entire group, having the Trainees indicate the method(s) used to solve each problem. Trainees should self-correct their own problem set. Conclude the session by having each Trainee prepare a list of mathematical skills they will obtain or improve during the course of the training program.

Trainer Notes: It will be important to emphasize to Trainees that this is not a pass/fail test but rather an indicator for each Trainee to identify personal needs to improve basic math skills. If Trainees are unable to solve even a single problem they are still fully entitled to participate in the training. They will want to allocate some personal time, however, to rapidly bring their math skills up to a level where they can accomplish many of the more demanding technical designs and computations required in upcoming sessions.

Materials Required:

* photocopied conversion tables
* photocopied problem sets
* scientific calculators (one per Trainee)

Selected References:

Appendix A, Irrigation Reference Manual: Conversion Factors; Trigonometric Table

Session Topic: Tool Use and Safety

Session Goal: For Trainees to identify techniques for using typical tools and machinery properly and safely.

Session Objectives:

(1) To have Trainees identify and describe the proper function of the tools commonly used in irrigation projects.

(2) To list ways to care for and protect tools.

(3) To list safety tips for working with tools at construction sites.

Overview: Volunteers must assume some level of responsibility for their own safety and the safety of others with whom they will work in implementing construction projects. Developing and demonstrating the proper use of common tools is an essential component of this work.

Session Activities:	
Time	
10 Min.	Begin session outside in a place where tool use can be easily demonstrated. Introduce objectives of session and ask Trainees to list common tools used for irrigation projects. Flush out list to include tools and equipment missed by Trainees and tell Trainees that list will be typed and distributed to them to include in their reference notebooks.
20 Min.	Trainer brings out tools for Trainees to inspect. A Trainee familiar with each tool is asked to demonstrate how the tool is properly used and safely cared for.
20 Min.	Trainees generate list of tool safety tips:
	- Don't leave tools scattered around work site.
	- Ensure personal protection (hands, face).
	- Check equipment before use to see if it has adequate strength and durability. (This is especially important when working with ropes, buckets, baskets, or lifting materials.)
	Trainees identify ways to care for tools:
	- practice proper storage,
	- define person responsible for tools,
	- clean tools after use,
	- replace or repair defective parts,
	- and learn how to use local materials where possible.
	Trainees list site safety tips:
	- know what other people around you are doing,
	- notice where tools are,
	- notice pits, holes, sharp edges, etc.,
	- be aware of the power of tropical heat, and
	- know how to lift heavy objects.
10 Min.	Trainer concludes by reminding Trainees that they will be accountable for tool use and maintenance throughout the training. All lost tools must be replaced at Trainees expense.

Trainer Notes: Trainers should refer to the List of Common Tools in Appendix A and identify those tools that are most appropriate for in-country conditions. These tools should be on hand at the training site and brought to this session.

Materials Required:

* flip chart
* handout of common tool list
* tools selected from tool list in Appendix A

Selected References:

Appendix A, Irrigation Reference Manual: List of Common Tools

Exam: Section 1- Math skills assessment

The following questions can assist Trainees to identify math skills that they might want to acquire or strengthen in order to work confidently with technical problem solving at their sites. The questions are intended to increase in complexity as one proceeds through the self-examination. In presenting the skills assessment to Trainees, it is important to emphasize that this is not a pass-fail test but rather an opportunity for them to conduct a self-assessment of their own skill levels.

1. A storage tank holds 1.5 cubic meters of water.

- How many gallons is this?
- How many liters?

2. 3 cubic meters of gravel + 2 cubic meters of sand + 1 cubic meter of cement = 3 cubic meters of concrete. You will pour a concrete slab that measures 3 meters by 5 meters by 10 centimeters.

- Approximately how many cubic feet of concrete will you need?
- How much gravel, sand, and cement (in meters) will you need?

3. You are planning to construct a concrete water storage tank. Each wall measures 2 meters high by 3 meters wide. You will need to purchase reinforcing bar to reinforce the walls. The bars are to be spaced 20 centimeters apart both horizontally and vertically.

- How many 2 meter lengths are needed? How many 3 meter lengths? (for 4 walls)
- If reinforcing bar can only be purchased in 6 meter lengths, how many bars will you need to purchase?

4. A hollow block measures 20 centimeters high and 40 centimeters wide. You want to build a retaining wall 2 meters high by 4 meters wide. Approximately how many blocks will you need, assuming none break in transport?

5. A truck carries 4 cubic meters of sand/gravel. You estimate that you will need 30 cubic feet of gravel and 100 cubic feet of sand. Can it bring you the sand and gravel in one trip?

6. 16 gallon wire sells by the kilo (one kilogram = 54 meters). A kilo sells for 20 pesos. You estimate that you will need 200 meters of wire. How much will it cost?

7. The flow from a spring is 8 liters per minute (Lpm). Assuming a constant rate, how many liters per hour and cubic meters per hour is this? How many gallons per hour?

8. Find the volume of this tank in cubic meters: inside depth = 5 m, outside walls = 6 m, wall thickness = 0.25 m.

How many liters of water will it hold?

9. The flow rate in a stream is estimated to be approximately 50 L/sec. or 180 m^3 /hr. You want to divert the stream to irrigate 1 hectare (10,000 m^2) of pasture. The hay requires 10 cm (0.1 m) of water to be applied in an irrigation. How long will you need to maintain the diversion to fulfill these water requirements?

Bonus Question

10. After surveying, you find that the difference in elevation between a water source and an irrigation distribution canal is 30 meters. The horizontal distance from the water source to the canal is 120 meters. Approximately how long a length of pipe will be needed to run from the source to the canal, assuming the slope of the hill is constant?

Sample Completed Test

1. A storage tank holds 1.5 cubic meters of water.

- How many liters is this?

Answer: 1.5 m^3 x 1000 liters/m^3 = 1500 liters

- How many gallons is this?

Answer: 1500 liters/3.8 = 395 gallons

2. 3 cubic meters of gravel + 2 cubic meters of sand + 1 cubic meter of cement = 3 cubic meters of concrete. You will pour a concrete slab that measures 3 meters by 5 meters by 10 centimeters.

- Approximately how many cubic meters of concrete will you need?

Answer: 1.5 cubic meters x (3.28 ft/1 m)^3 = 52.9 ft^3

- How much gravel, sand, and cement (in cubic meters) will you need (using the given ratio of 3:2:1)?

Answer: 1.5 m^3 gravel, 1 m^3 sand, 0.5 m^3 cement

3. You are planning to construct a concrete water storage tank. Each wall measures 2 meters high by 3 meters wide. You will need to purchase reinforcing bar to reinforce the walls. The bars are to be spaced 20 centimeters apart both horizontally and vertically.

- How many 2 meter lengths are needed? How many 3 meter lengths? (for 4 walls)

Answer: 60 and 40 respectively

- If reinforcing bar can only be purchased in 6 meter lengths, how many bars will you need to purchase?

Answer: 40

4. A hollow block measures 20 centimeters high and 40 centimeters wide. You want to build a retaining wall 2 meters high by 4 meters wide. Approximately how many blocks will you need, assuming none break in transport?

Answer: Number of blocks = area of wall / area of individual blocks = (2 m x 4 m)/(0.2 m x 0.4 m) = 100 blocks

* Note: This assumes the mortar joints take up no space

5. A truck carries 4 cubic meters of sand/gravel. You estimate that you will need 30 cubic feet of gravel and 100 cubic feet of sand. Can it bring you the sand and gravel in one trip?

Answer: Volume of sand and gravel = 30 cubic feet + 100 cubic feet

130 cubic feet/35 cubic feet per cubic meter = 3.7 m^3; thus, yes.

6. 16 gauge wire sells by the kilo (one kilogram = 54 meters). A kilo sells for 20 pesos. You estimate that you will need 200 meters of wire. How much will it cost?

Answer: 200 m/54 m = 3.7 kg x 20 = 74 pesos

7. The flow from a spring is 8 liters per minute (Lpm). Assuming a constant rate, how many liters per hour and cubic meters per hour is this? How many gallons per hour?

Answer: 8 x 60 = 480, 480 liters/hr = 0.48 m^3/hr
480/3.8 = 126 gallons/hr

8. Find the volume of a tank in cubic meters if the inside depth is 5 meters and the lengths of the outside walls are 6 meters. Wall thickness is 0.25 meters.

- How many liters of water will it hold?

Answer: 5.5 x 5.5 x 5 = 151.25 m^3 = 151,250 liters

9. The flow rate in a stream is estimated to be approximately 50 L/sec. or 180 m^3 /fur. You want to divert the stream to irrigate 1 hectare (10,000 m^2) of pasture. The pasture requires 10 cm (0.1 m) of water to be applied in an irrigation. How long will you need to maintain the diversion to fulfill these water requirements?

Answer: Area x depth = flow rate x time
Time = (area x depth)/flow rate
Time = (10,000 m^2 x 0.1 m/180 m^3 /fur) = 5.6 hrs

Bonus Question

10. After surveying, you find that the difference in elevation between a water source and an irrigation distribution canal is 30 meters. The horizontal distance from the water source to the canal is 120 meters.

Approximately how long a length of pipe will be needed to run from the source to the canal, assuming the slope of the hill is constant?

Answer: $(30)^2 + (120)^2 = x^2$
$x^2 = 900 + 14,400$
$x^2 = 15,300$
$x^2 = 123.7$ meters

Section 2: Community organization and mobilization

*** Conducting a Community Needs Assessment**
*** Community Organization and Mobilization**
*** Communication Techniques**
*** Problem Solving**
*** Working with a Community Water Users Association**
*** Construction Projects in a Community**
*** Exam: Section 2 (Community Participation)**

Session Topic: Conducting a Community Needs Assessment

Session Goal: For Trainees to identify important attributes and resources within their communities that will support irrigation or other project developments.

Session Objectives:

(1) For Trainees to describe how they will use community assessments at their work sites.

(2) For Trainees to list the information needed to assess the resources in a community.

(3) For Trainees to identify various ways that this information can be gathered without disrupting or raising unnecessary suspicions in a community.

(4) For Trainees to identify pitfalls and problems they are likely to encounter doing community assessments.

(5) For Trainees to prepare a community survey form that they can use during their Volunteer service.

(6) For Trainees to gain field experience conducting rapid needs assessments in a rural community.

Overview: An initial task for Volunteers will be identifying human and physical resources available to support project efforts. Volunteers need to assess administrative, managerial, and technical skills that are present in their communities and document equipment, tools, and other physical resources that can be reliably applied to project needs. During the training it is expected that Trainees will work with small projects in local communities. This session will give Trainees an opportunity to begin interacting with this participating community and organize information that will help their training field projects.

Session Activities:	
Time	
15 Min.	Have Trainees brainstorm the process involved in developing a total project or program plan. Example:
	Problem Identification and Analysis
	Needs and Resource Assessment
	Project Plan and Design
	Implementation Administration Evaluation
	Operations and Maintenance
	The discussion should include a description of ways of viewing "needs" before going out to collect data. "Needs" can be defined to include:
	- felt needs - a wish list, unrestrained by cost, reality and priorities;
	- expressed needs - needs expressed by people's actions;
	- normative needs - needs seen from the perspective of experts in the field or public officials; and
	- comparative needs - needs resulting from inequalities in abilities, services, or resource availability.
10 Min.	Have Trainees select a facilitator to record ideas. The trainers should move to the back of the room and let the Trainees run the session from here on out. Trainees can brainstorm specific topics that should be included in conducting an analysis of the resources available and needs that must be met to support projects in a community. The resource topics should include physical and human resources, and the needs assessment should identify community concerns and problems (e.g., health, skills, materials, and finances). Trainees should compile a comprehensive list of topics on a flip chart and then organize the topics by category, recognizing that not all of this information may be needed for every project. Data requirements are project specific, and there is no need to collect data just for the sake of having data. The Trainees should then describe unobtrusive methods that they can apply to collect this information. Examples include:
	- reading and observing,
	- interviews with local officials,
	- informal interviews and conversations with local people,
	- public meetings, and
	- participation of villagers in your work activities.
	Trainer should remind Trainees that this data collection must be done in a manner that does not arouse suspicions about a Volunteer's motives and Trainees should identify measures for ensuring that the community is supportive of the data collection (for example, have someone from the community do the information collection). Trainer should pull group back together with a discussion of situation analysis and needs assessment processes. This discussion should include:
	1. One shot "complete" assessments versus a continuous process that recognizes that as people get more experience and exposure the inventory process improves.

	2. The evolutionary nature of needs. At first, people only assess immediate needs. As these initial needs are met, people move on to new needs and long range plans. Also, people's perceptions of needs and problems typically expands with time and participation. Project planning requires a flexible process that can accommodate this evolutionary nature of needs.
	3. Need and resource assessment must be a participatory process, and not a blueprint approach done by "experts". Again, the Volunteer's role is to facilitate, motivate, and guide.
	4. The importance of communication skills, especially active listening and the use of open-ended questions.
	5. The influence of cultural factors and sensitivities (politeness, protocol) on obtaining misleading information.
	6. Visible versus invisible needs or resources. Actual relationships, indebtedness, and transaction processes in the community may be very different than what initially appears on the surface.
20 Min.	Trainer should explain to Trainees that they will now divide into groups of three and go into a nearby community to collect information that would support a small-scale irrigation project plan. Trainer should provide a brief background on the social and environmental conditions in the community and draw a simple community map to help Trainees avoid getting lost. This task is best accomplished by having the trainer assign each group specific topics to research and by having the groups dispersed in more than one community. The groups should decide on their own how they will organize their effort, delegate responsibilities, and consolidate the data.
180 Min.	Trainees are transported and left in a central point in each community. A specific time and place for retrieving the Trainees will be determined, and at the conclusion of the field data collection, the Trainees are transported back to the site.
40 Min.	Trainer asks each group to prepare a brief presentation describing the following:
	- In general, what happened during your survey?
	- What information did you obtain?
	- What problems or pitfalls did you encounter?
	- What might you have done differently, and how otherwise would you have done it?
	- How do you feel you will apply these skills in your work at your site?
10 Min.	Trainer summarizes session by discussing the relationship between accurately assessing community resources and needs and mobilizing and organizing communities.

Trainer Notes: This session requires a great deal of preparation. Communities must be identified and prepared to receive Trainees. Trainers should be prepared to transport Trainees to perhaps several remote locations. In some in-country situations, language skills may be a constraint and may prevent Trainees from working in the field. In these instances, the field session can be eliminated, and this session can be done in the classroom as a role play. Divide the Trainees in half and have one group represent the community members while the other half conducts a needs assessment. Doing the session in the classroom should reduce the total time required by a factor of three.

Materials Required:

* clipboards, pens or pencils
* vehicle transport
* patience

Selected References:

Appendix B. Irrigation Reference Manual: Community Situation Analysis/Needs Assessment

Session Topic: Community Organization and Mobilization

Session Goal: For Trainees to identify and describe techniques they can use to mobilize community participation in projects.

Session Objectives:

(1) For Trainees to describe techniques or strategies that can help mobilize a community for a development project.

(2) For Trainees to practice group decision making and identify important decision-making skills.

(3) For Trainees to practice organizing community support and participation in their field projects.

Overview: This session should be done prior to initiating any field work projects. It combines basic theoretical concepts of community development with an opportunity for Trainees to plan how they will involve community members in their field work.

Session Activities:	
Time	
30 Min.	Trainer should present visually and descriptively one or two case examples of community involvement in small-scale irrigation systems. For each case, have the Trainees list the important steps to follow in organizing and mobilizing communities. For example,
	1. Visiting community, both formally and informally.
	2. Identifying community leaders and determining community roles and responsibilities.
	3. Conducting a meeting in the community to identify problems and explore issues around irrigation projects.
	4. Working with community members to conduct a baseline community needs and resources assessment.
	5. Facilitating the development of a water users association (if not already in place).
	6. Facilitating water users association design and implementation of project activities: a. meetings with community organization leaders, b. contacts with owners of commercial establishments, farmers, and financially important community members, c. meetings with other organized community groups, d. meetings with school teachers, and e. development of support groups.
	7. Implementing project: a. defining community contribution to the project (labor, money, materials), b. preparing agreements and contracts, c. defining roles and responsibilities, and d. establishing administrative structure.

120 Min.	Trainers transport Trainees to their proposed work sites for field projects. The Trainees should have already made arrangements with people from the community to have a community meeting (this can be done through the trainers, if necessary). The Trainees should have informed people in the community that the objective of this meeting is to present ideas about the field projects the Trainees want to do and identify ways in which the community members might want to get involved. It is best to have divided the Trainees into groups of four or less and have each group work with different organizations or activities in the community. The Trainees should be prepared to lead a meeting, present diagrams and descriptions of their project ideas, answer questions, generate enthusiasm for the activity, and organize a work schedule. The actual project to be undertaken should be small and simple enough to be accomplished in a very limited time frame and be only a very minor demand on community members' time.
30 Min.	Return to the training site. Trainers should facilitate an open discussion of the Trainees' experiences. The discussion should identify both successful and ineffective techniques and strategies used to motivate and expedite community participation in the proposed project. Conclude session by having Trainees state what measures they will use to ensure that the community will continue to be integrated into the planning and completion of the field work.

Trainer Notes: This session requires some prep work for the trainers. Community members need to be very clear as to the purpose of the field work and of the Trainees request for help. Trainers should also be prepared to respond to frustrated Trainees, who may quickly discover how little extra time and energy is available in many rural communities. If the field project activities are not being done in active community settings, then this session can be done in the classroom as a role play. Divide the Trainees in half and have one group represent the community members while the other half attempts to mobilize them. Doing the session in the classroom should reduce the total time required by a factor of three.

Materials Required:

* transport
* visual aids, presentation materials (Trainees need these for their community meeting)

References:

Appendix B. Irrigation Reference Manual: Water Users Associations Appendix D, Irrigation Reference Manual: Case Studies

Bunch, R. 1982. Two Ears of Corn: A Guide to People-Centered Agricultural Improvement. World Neighbors, Oklahoma City, Oklahoma. pp. 18-36 and 57-70.

Session Topic: Communication Techniques

Session Goal: For Trainees to participate in exercises that will enable them to test and strengthen their ability to communicate ideas, feelings, and symbols.

Session Objectives:

(1) For Trainees to identify skills that facilitate effective communication.

(2) For Trainees to apply these communication skills in both formal and informal settings.

(3) For Trainees to identify communication skills they intend to improve during the course of the training.

Overview: Much of the Volunteers' effectiveness on the job and personal satisfaction living in a rural community will depend on their skills in communicating with people of another culture. Successful Volunteer

projects require a sense of trust and goodwill to be developed, and this, in turn, will be determined by the Volunteer's ability to communicate ideas and feelings clearly and confidently. During their service Volunteers may find themselves conducting training workshops for rural community members, organizing and facilitating group meetings, participating in detailed planning and decision-making sessions, meeting with government officials, or simply stopping to chat with people in the street. In all of these settings, the success of their relations will depend upon the strength of their communication skills. This session provides Trainees with opportunities to identify basic skills that can make any communication effort successful. Trainees then participate in exercises to test their abilities to apply these skills.

Session Activities:	
Time	
15 Min.	Trainer introduces session by facilitating brief definition of communication and description of what is involved in the communication process. Trainer should emphasize that communication is the process by which two individuals attempt to exchange a set of ideas, feelings, symbols, and meanings. Communication occurs both with and without language. We communicate with our facial expressions and other body language and often through some other visual form (e.g., pictures, symbols). Trainer should ask Trainees to identify the causes of misunderstanding and misinterpreted messages. What are the factors that tend to promote communication versus those that seem to prevent us from conveying an idea or feeling? In what ways does "culture" influence this communication process? Trainees should then list factors they feel are intrinsic to promoting communication between peoples of different cultures.
20 Min.	Trainees each select a partner, grab a piece of paper and a color pen. One person will act as the "sender" and the other person will be the "receiver." While sitting back to back, the sender will draw a picture, and then describe his or her drawing in such a way that the receiver can replicate it on his or her own paper. During this process, the receiver cannot communicate in any manner other than to listen carefully and try to draw what the sender is describing. After 10 minutes, the exercise is stopped and the two drawings are compared. Trainer should bring the group together again and have each pair discuss their experience. Notice which details are left out and how details were altered. Discuss factors that influence our "filtering" of information as we receive and process it.
15 Min.	Trainer should select four partners from the Trainee pairings and ask each pair to describe how they might improve the four basic skills essential to any communication exchange: 1) active listening, 2) asking questions, 3) feedback, and 4) non-verbal cues. If there are language instructors or others from the host country available, they can apply the Trainee descriptions of these skills to their own culture through example.
10 Min.	Trainer concludes with discussion of the impossibility of "pure" communication and the influence of our own perceptions and filtration devices. Each person has her or his own construction of "reality,"' and this is very much influenced by the social conditions in which we have been raised and now live. By recognizing and working with these four basic communication skills we can find that the messages we send through language, drawings, or simple body language can be more effectively received. As Volunteers, the use of communication skills will be applied daily in doing extension work, conducting workshops, identifying problems, planning projects, and just everyday social interactions. Strengthening communication skills is perhaps the Volunteer's biggest and most important challenge. Other opportunities will occur throughout the training for Trainees to work with these skills. (If time and interest permits, the drawing exercise can be repeated, with the sender becoming the receiver and the receiver the sender.)

Trainer Notes: If language instructors are part of the training, it may be useful and interesting to have them participate as one part of the drawing team. This adds a valuable cross-cultural dimension to the exercise, which may not come across if it is merely Trainees working among themselves.

Materials Required:

* drawing paper, colored pens or pencils
* flip chart or other visual aids to describe four basic communication skills

Selected References:

Appendix B. Irrigation Reference Manual: Communication Techniques

Session Topic: Problem Solving

Session Goal: For Trainees to develop skills that will enable them to anticipate typical problem situations and develop effective solutions.

Session Objectives:

(1) For Trainees to identify cultural factors that define and influence how we define and respond to problems.

(2) For Trainees to list a series of steps that can be taken to solve any problem they might encounter, technical or personal.

(3) For Trainees to identify possible problems they anticipate after arriving at their site and to select solutions to these problems that should work for them.

Overview: The personal techniques we use to solve problems, and the degree to which we are successful in solving them, essentially determines how well things work out in our lives. Volunteers will encounter a succession of personal and professional problems throughout their period of service. Their ability to create positive solutions to these problems will determine the degree of fulfillment they feel personally and which their community will experience as a result of their Volunteer efforts. In this session Trainees identify the cultural and personal factors that cause us to identify a situation as a "problem" in the first place. A role-play exercise is used to enable Trainees to map out steps that can be applied to any problem situation. Trainees then spend time individually anticipating the kinds of problems they are likely to encounter after completing the training and the kinds of responses they know will work to solve these problems.

Session Activities:	
Time	
10 Min.	Trainer begins by stating that "problems" are really just "opportunities" - it all depends on how you look at things and how flexible you are in figuring out solutions. Trainer can provide the following examples:
	Given the Roman Numeral IX, use one line to make this "nine". into a "six" answer. Solution: S + IX = SIX. (No one said the answer had to be a Roman Numeral! Listening skills again)
	Given …
	Use 4 lines to connect all of the dots. (No one said you had to stay within the boundaries of the lines! Listening skills again ....)

25 Min.	Trainees participate in a role play in which one Trainee feels that everything in his or her life is going wrong. No one at the site will talk to them, there is way too much work, and it is ridiculous anyway to assume that an untrained person could ever develop an irrigation system that would really work. The Volunteer is considering giving up and just going back home. The other Trainee, after listening carefully, begins to ask questions that lead to the true cause of the "problem": the frustrated Volunteer is simply lonely and is masking that loneliness by working on building a project day and night, with little break in effort. The friend asks the frustrated Trainee if he or she has felt this before and then asks what kinds of things have worked in the past to deal with feeling lonely or out of place. The friend asks the frustrated Trainee to be honest about which solutions he or she is most likely actually to pursue and to describe why. Once the friend feels some sense of commitment from the frustrated Trainee about the preferred solutions, then the frustrated Trainee is asked what he or she will do to get out of this rut and when he or she will start to take action. The guiding friend asks the troubled friend to send a postcard in a few weeks to say how it is all going.
25 Min.	Trainer leads Trainees through discussion in which they list the steps taken by the 'guiding friend" to help the troubled friend solve the problem. These steps should depict problem solving as:
	1. setting a positive environment that feels supportive, and in which solutions seem possible;
	2. defining the problem as precisely as possible;
	3. discussing possible solutions;
	4. identifying the pros and cons of each solution;
	5. selecting a solution;
	6. developing an action plan; and
	7. after initiating action, taking time to reflect and evaluate your results. If the solution needs modification, just build it into the effort.
	Trainer emphasizes that these steps are applicable to any problems, be they technical concerns-about irrigation or personal concerns. Trainees list concepts or language that can get in the way of constructive problem solving:
	- replaying the past in your mind,
	- having vague goals,
	- making judgments about others and allowing these judgments to influence your problem definition and possible solutions,
	- using the words never, impossible, can't, try, limitation, if only, but, difficult, ought to, should, and, doubt, and
	- using any words that tend to measure, judge, or condemn you or someone else.
	Trainer describes the value of creative, positive visualization as a problem-solving tool. Try to see what the "problem" looks like when it is "solved" or what life looks like without the "problem." Develop a very clear picture of this in your mind. Then allow yourself to visualize steps that occurred to create this positive vision. Trainer concludes by having Trainees describe other such techniques that work for them to fulfill the 7-step problem solving procedure.

Trainer Notes: Case studies can be used as examples of problems to be solved, although the emphasis must be placed on the process used to solve the problem and not necessarily the solution.

Materials Required: None

Selected References:

Appendix B. Irrigation Reference Manual: Problem Solving Appendix D, Irrigationf Reference Manual: Case Studies

Session Topic: Working With A Community Water Association

Session Goal: Trainees will describe the role, function, and structure of a typical water users association and describe the role of a Peace Corps Volunteer in working with these associations.

Session Objectives:

(1) Trainees will describe the functions and structure of a water users association.

(2) Trainees will participate in a role play to identify typical problems and constraints in maintaining associations.

Overview: Well organized and administered water users associations can ensure effective operation and maintenance of irrigation systems. In this session Trainees work with skills developed in the Communication Skills, Community Needs Assessment, and Community Organization and Mobilization sessions to identify needs and problems in working with associations.

Session Activities:	
Time	
15 Min.	Trainer will present a brief overview of the structure and functions of a hypothetical water users association and describe the role that this association is playing in operating and maintaining a local irrigation system. This overview sets the stage for the subsequent role play but should also serve as a concise but comprehensive overview of organizational and administrative needs in forming and sustaining water user groups.
30 Min.	Trainees divide into two groups. One group, comprised of two Trainees, represents recently arrived extension workers who are trying to become familiar with local irrigation practices. A second group with 3-4 Trainees will represent members of the water users association. The extension workers have arrived to interview the water users association to learn the following:
	- What are the typical crops being planted and how are local people managing the cropping pattern in the valley?
	- What kinds of operation and maintenance practices are the association using to manage water?
	- What kinds of problems are the farmers finding, and how is the association helping local farmers work with their problems?
	- How often does the association meet, and can the extension workers attend the next meeting?
	The trainer should coach the Trainees acting as the association members before the role play. Give the Trainees suggestions for a few personal problems within the association in an effort to make this exercise at least a bit realistic.
15 Min.	Trainees assess the role play and identify important considerations that must be resolved in establishing or working with a water users association. Trainees develop a list of procedures that can be used to resolve disputes in groups. Trainer provides a brief overview of several local water user associations and discusses some of their strengths, weaknesses, problems, and accomplishments.
60 Min.	Trainees visit representatives of a local water users association and interview them about organizational structure, administrative procedures, member responsibilities, and overall objectives.

Trainer Notes: It is important to make the role play realistic and not just a funny dialogue. Trainers should coach the Trainees acting as association representatives, and give them some basic information about the hypothetical group they represent. Trainer should visit with a local water users group and provide them with some background on the training objectives and Trainees skill levels.

Materials Required:

* transport

Selected References:

Appendix B. Irrigation Reference Manual: Water Users Associations

Session Topic: Construction Projects in a Community

Session Goal: For Trainees to identify technical and cross-cultural skills they want to further develop to facilitate their community projects.

Session Objectives:

(1) For Trainees to examine and evaluate the construction of projects in a community as a cross-cultural experience.

(2) For Trainees to describe the relationship between their community construction projects and the work they anticipate doing as Volunteers.

(3) For trainers to provide feedback on Trainee construction projects.

Overview: This session, best done at a mid-point in the training, provides trainers and Trainees an opportunity to review field work to date and identify the cross-cultural, as well as technical, [earnings that result from the field work. This session should be done as an informal dialogue between the trainer(s) and Trainees, without any structured activities.

Session Activities:	
Time	
30 Min.	Trainer should assemble the following questions on a flip chart, and then ask the Trainees to discuss as a group their responses to each question. Trainer should reveal only one question at a time to avoid having Trainees responding to all questions at once.
	- What have been your major problems or frustrations in the field project work? What personal changes did you need to make in order to adjust to these problems?
	- What do you perceive to be the community's view of Peace Corps and of you as Volunteers? In what ways do you feel you influenced that perception?
	- What did you observe to be the strong social institutions in the community? In what ways did you feel a part of them or separate from them?
	- What technical knowledge related to the field work did community members demonstrate? How did you work with their skills and incorporate them into the effort?
	- What impact did the physical work environment have on your field work? How did you adjust to the environment?
	- What were the main positive aspects of working in the community?
	Trainer should summarize key points and concepts being made by the group on a flip chart and then conclude by linking this information to material covered in the sessions on Conducting a Community Needs Assessment and Community Organization and Mobilization.

Exam: Section 2-Community participation

1. Describe the typical structure of a water users association. What are typical problems and pitfalls that can occur in organizing and maintaining such an association?

2. Describe five functions of a community water users association.

3. Describe five typical indicators that reflect strong community interest in a project.

4. Identify and describe two methods to assess community resources. Describe which method is more appropriate in your opinion and why.

5. A community has invited you to come and explain what is required to put together a basic irrigation system. Unfortunately, this community speaks an unusual tribal dialect, and you know only a few words in their language. Still, there you are, and the villagers are awaiting your explanation. Convey the information as best you can without using language.

6. You and your neighbor have built a very small irrigation system on your own, without consulting other people in the village. You had decided that this was okay, since the system was intended to water only your and your neighbor's gardens, and no one else seemed to express any interest in connecting into the system. Unfortunately, the canal to your neighbor's property overflowed during a recent flood and completely washed out his neighbor's garden, who also happens to be an important village leader. Not surprisingly, the flood also wiped out many other people's fields. The village leader, however, is irate, and blames you and your neighbor for the loss of crops. Your neighbor is hopelessly depressed and rarely comes out of his house. The village leader is telling others that they should be very careful about seeking your advice, since your canals obviously don't work. You decide that you clearly have a problem here, and you had better deal with it quickly. Describe the steps you would take to organize a solution to this problem.

7. Describe three techniques you would use to stimulate community interest in a project.

Section 3: Inventorying the physical and biological resource base

*** Watershed Hydrology**
*** Water Flow Measurements**
*** Surveying and Field Measurements**
*** Soil-Plant-Water Relationships**
*** Conducting Environmental Assessments**
*** Exam: Section 3 (Field Measurements)**

Session Topic: Watershed Hydrology

Session Goal: To enable Trainees to identify potential water supplies for irrigation projects and to manage soil and water resources sustainable within an irrigation project area.

Session Objectives:

(1) Trainees will be able to demonstrate graphically the basic concepts of the hydrologic cycle and describe important physical factors influencing availability of surface and ground water supplies.

(2) Trainees will be able to delineate watersheds using topographic maps and field observations.

(3) Trainees will be able to identify potential sources of water using available maps and field observations.

Overview: One of the first tasks facing irrigation Volunteers will be to identify water sources that can be managed to supply an irrigation project over a long term period. To do this work, they will need to understand basic hydrologic concepts and soil and water conservation principles.

Session Activities:	
Time	

75 Min.	Trainer displays a large picture with all of the key components of the hydrologic cycle but without any flow connections. Include in the picture a diversion dam and canal running to an agricultural field. Also include a diversion running to a storage pond and several wells. Ask for a Trainee to use the drawing to show the movement of water in the hydrologic cycle, including the influence of such engineered actions as stream diversions and wells. Encourage other Trainees to help if this Trainee has any problems. Trainer then delivers a brief lecture describing each process of the cycle, including typical procedures and units for measuring each factor. Have Trainees identify all potential sources of water in the hydrologic cycle and describe techniques that can be used to tap these sources. Trainer should then expand on this information, describing surface water and ground water hydrology. Include in this discussion information on the formation of rivers, streams, and springs, and some basic information on water quality. Trainees need to understand that water quality is a relative term that describes a set of conditions we want to maintain. Good water quality for irrigation will differ from the water quality needed for potable systems. Trainer should discuss some of the parameters important for irrigation projects and indicate how these parameters are measured. The trainer should conclude by facilitating a description of all of the factors involved in assessing the "condition" of a watershed, describing the tools commonly used for conducting such an analysis, and having the Trainees outline a process or set of procedures they would follow to do a watershed assessment. The trainer should be certain to demonstrate graphically factors that can be used to identify a watershed in a declining or healthy condition. The group should now take a short break before reconvening outside.
60 Min.	Trainer should bring Trainees to an outdoor location where they can investigate hydrology in the field. Trainees are provided with a topographic map and instructed to delineate a specific sub-watershed and map all of the drainage's, ponds, or lakes in this sub-watershed. They should then walk the watershed and prepare a written description of watershed conditions, determining the sensitivity and resilience of the basin.
15 Min.	Trainer should conclude session by indicating the role of watershed management and soil and water conservation in small-scale irrigation systems and by encouraging Trainees to think of the watershed as the boundary in which they should plan all of their irrigation projects.

Trainer Notes : If the Trainees have a confident understanding of the process and procedures involved in assessing watershed conditions, then this situation flows more quickly.

Materials Required:

* compass
* topographic maps
* visual aids depicting hydrologic processes

References:

Chapter 2, Irrigation Reference Manual: Watersheds

Session Topic: Water Flow Measurements

Session Goal: To enable Trainees to measure and calculate water flow in small streams, canals, and springs.

Session Objectives:

(1) Trainees will be able to determine the most appropriate method for measuring flow rates in the field.

(2) Trainees will be able to site, construct, and install simple streamflow measuring devices.

(3) Trainees will obtain field experience in measuring the flow rates of small streams, canals, or springs using several different methods.

Overview: It is essential for irrigation Volunteers to determine accurately and consistently the volume and rate of water available to supply irrigation systems. This session builds on work in previous sessions in basic hydrology, watershed management, and basic hydraulics. Having learned how weather, land forms, and physical constraints affect the movement of water in nature, Trainees now obtain some hands-on experience estimating flow rates in streams and canals using very simple measurement techniques.

Session Activities:	
Time	
30 min.	Trainer will introduce section by presenting a lecture on streamflow measurement units and standard flow measurement devices. Lecture will relate back to basic hydrologic principles, indicating seasonal variations in flow rates and the influence of watershed conditions on flow characteristics. The use of topographic maps will be emphasized in selection of sites for field measurements. Trainer will demonstrate simple measurement practices in the classroom using a "bucket" method, a "float" method, and the use of constructed weirs. Throughout the lecture the trainer will emphasize the need to rely on locally available materials and the importance of ensuring accuracy in measurement tests. Trainer will demonstrate basic calculations and use of simple tables and graphs to facilitate measurement practices. At the end of the lecture, the trainer will divide the Trainees into groups of three and distribute materials for field work.
90 min.	Trainer will lead Trainees into the field where they will work in teams of three experimenting with flow measurement strategies at a small stream, canal, or spring site. Each team of Trainees will select a site in which to conduct sample flow measurements. The team will then use locally available materials to conduct or construct, as necessary, the appropriate measurement technique. Trainees will use the "bucket," "float," and weir methods to measure flow. Estimated flow rates for each method will be recorded by the Trainee teams.
30 min.	Trainer will lead groups back into the classroom and the teams will compare measurement results. The trainer will facilitate a discussion of probable reasons for any variations in flow estimates, typical problems that may arise to influence the accuracy of measurement readings, and areas in which Trainees feel they will need further work.

Trainer Notes: Few Trainees will have had field experience in measuring and recording natural flow rates from streams, canals, or springs. Initial efforts by Trainees are likely to yield a few significant inaccuracies in estimating flow rates, and this can result in serious problems when judging the capabilities of a water source to meet proposed irrigation system requirements. It will be very important for the trainer to take the lead in instructing and guiding Trainees to apply the basic measurement concepts. The trainer should be prepared to present a concise lecture on flow measurement techniques and respond to field measurement questions concerning the use of tables to estimate water flow rates over a constructed weir and preferred site locations for taking measurements.

Materials Required:

* 100-foot tape measure
* carpenter's level, hammer, hand saw, shovels
* one to four 5 gallon buckets
* plywood sheets or other scrap wood boards
* PVC pipe of various lengths and diameters (diameter size will be dependent on flow rates)
* scrap pieces of sheet metal
* stopwatches

* string and flotation object
* stakes

Selected References:

Chapter 2, Irrigation Reference Manual: Water Measurement International Irrigation Center Module #32

Jordan, T. D. 1984. A Handbook of Gravity-Flow Water Systems, Intermediate Technology Publications, pp. 812. Technology Publications, pp. 128-30.

Session Topic: Surveying and Field Measurements

Session Goal: Trainees will be able to perform surveying techniques to map a field as part of planning irrigation systems.

Session Objectives:

(1) Trainees will construct and calibrate an A-frame level.

(2) Trainees will perform a mapping exercise in which they will determine the area and major slopes of a field, and sketch in the different types of vegetative cover and natural waterways of a field.

(3) Trainees will determine the elevational difference between two points using several alternative surveying techniques: hand and Abney level, carpenter's level, and line and water level.

(4) Trainees will lay out a field in a grid pattern, determine the elevational differences at each point, and sketch a topographical map of the area.

Overview: Surveying practices to determine land topography are an essential component in the planning of an irrigation system. Surveying skills are essential in order to allow Trainees to confidently design systems, and assess water supply and erosion conditions. This session provides Trainees with opportunities to work with several surveying techniques, enabling them to accomplish survey needs where tools and equipment may be limited.

Session Activities:	
Time	
30 Min.	Trainer presents a drawing of a field and asks Trainees how they will determine the topography and area of this field. Trainer records suggested techniques on a flip chart. Trainer then presents brief lecturette on four surveying techniques which can be performed with minimal equipment: A-frame; carpenter's level; hand or Abney level; or other appropriate level. Trainer should have an example of the materials used for each technique in the room, and demonstrate their use for the Trainees. Discussion includes methods for determining the number of points required in completing a survey, and proper techniques for recording data. Trainer facilitates Trainees to describe how these data can then be used to construct a topographical representation of the field in the drawing with which the session began.
30 Min.	Trainees break into groups of three and are given instructions to construct a simple A-frame level. Trainer allows them to work independently, but moves about answering questions. After completing their A-frame, the session moves to the field.

60 Min.	Trainers lead Trainees to a field, and the Trainees remain in their groups of three. Each group will be asked to mark out a contour line using the A-frame level. Then each group will be told to determine the area of the field, and the results of each group will be compared at the conclusion of the session. A first priority will be for Trainees to measure their "pace," or the length of one step. (A 'mace" can also be measured as the length of two steps, whereby every two steps equals one pace.) Trainees will then use an Abney level to determine slope percentage in the field. They should also experiment with other levels for estimating slope percentage and compare the results. After completing this task, Trainees should use the compass/string method to determine the area of the field.
60 Min.	Trainees experiment with the use of the hand or Abney level, carpenter's level, and other levels for measuring elevational differences. After the Trainees feel confident in the use of these techniques, the trainer assigns each group one of the methods and has the groups work sequentially to determine the elevation difference between two points in the field. After completing the exercise and recording the data, the groups compare their results and discuss advantages and disadvantages of each method.
30 Min.	Trainees mark the area of the field in a grid (squares) with stakes. Each group of Trainees selects a preferred method for measuring elevational differences and takes elevation differences off a benchmark, carefully recording the data. Trainer should try to make sure that several methods are applied. Trainees use the data to sketch a topographical map on graph paper. Trainer asks Trainees to describe all the information they can obtain from a topographic map and makes certain they feel confident making one. Trainer concludes session by asking Trainees to describe all the applications they can see for these surveying skills covered in the session.

Trainer Notes: It is important to select a field with some gradient to it, if possible. Trainers should also be certain that all equipment is functioning properly before beginning the session.

Materials Required:

* carpenter's level, hand or Abney level
* compass
* graph paper
* stakes (can be made by Trainees)
* string
* two stadia rods, 1/2" transparent tubing (for water line level)
* tape measure

References:

Chapter 2, Irrigation Reference Manual: Surveying; Profiling; Steps in Making a Topographic Map; Abney Level Surveying; Simple Levels for Use in Surveying Contour Lines; Compass Use Appendix A, Irrigation Reference Manual: Conversion Factors and Common Formulas

Session Topic: Soil-Plant-Water Relationships

Session Goal: Trainees will be able to demonstrate and apply basic concepts relating to physical characteristicsof soil, and describe the relationship to irrigation design, operation, and maintenance.

Session Objectives:

(1) Trainees will be able to identify different soil textures using the "feel" method.

(2) Trainees will be able to describe the relationship between soil texture, structure, and plant rooting to the size of the soil water reservoir available to the plant.

(3) Trainees will perform an infiltration test, assess the intake characteristics of the soil, and describe the factors that affect infiltration.

Overview: Certain basic relationships between soils, plants, and water must be understood before Trainees can do irrigation system designs or develop operation and maintenance plans.

Session Activities:	
Time	
30 Min.	Trainer presents brief lecture on soil texture, structure, and the relationship of these factors to aeration, permeability, water-holding capacity, and drainage. Trainer then brings out several bags of soil of varying soil texture. Trainees individually practice estimating soil texture using the "feel" method. Trainer should show Trainees how to form a ribbon between their fingers and encourage Trainees to make personal notes as to what factors are most important for them in getting an intuitive sense for this process. Trainer then brings out 2-3 soil samples in jars. Trainees are instructed to add water and a little bit of soap to the jars and then shake them up very vigorously for a minute or two. The jars are then placed on a level surface and left until the end of the session.
60 Min.	Trainer graphically presents a brief overview of the basic concepts of the movement and storage of water in soil, indicating how texture, structure, and plant rooting depths influence the availability of water to plants. Trainer takes Trainees out to a field and instructs them to work in pairs. Each pair should carefully dig holes to 1 meter in at least locations, examining the soil texture and structure and following plant roots in the soil. One hole (pit) may be made with a shovel, and another should be constructed with a soil auger. It is advisable to have Trainees work with some wet soils and some dry and to identify the characteristics that may be affecting the varying soil moisture in each location.
95 Min.	Trainer now instructs each pair to conduct an infiltration test. Trainees should build a 1 meter square basin in a level area with walls 25-30 centimeters in height. The wells should be well compacted. A thin piece of plastic should be placed on the bottom of the basin. The soil used to build the sides of the basins must come from outside the basin, since the soil surface inside the basin should not be disturbed in any manner. Trainees should have a ruler available to measure the water level and a watch to record time. One Trainee should work with the ruler and the other record data and keep track of time. Water can first be added to a small circle of land on the perimeter of the basin to avoid subsequent lateral migration of water from the area inside the basin. Water should then be poured into the basin to a starting depth of 15-20 centimeters. The water levels are then measured at intervals of 1, 2, 5, 10, 15, 30, 45, and 60 minutes. If the water depth reaches 10 centimeters before 60 minutes have passed, then additional water should be added and factored into the total amount applied. Trainees should be recording infiltration rates throughout this process. In between the water measurements, the trainer(s) can discuss the effect of soil texture, structure, compaction, and cultivation methods on infiltration processes, as well as the ways in which infiltration rates influence irrigation method selection and system design. Trainer(s) should also point out to Trainees how infiltration rates change with time and discuss some of the physical reasons that cause this. At the completion of the test, Trainees will use graph paper to plot time versus cumulative infiltration in centimeters.
5 Min.	Trainees can return to inspect the soil samples in their jars and compare the different methods for approximating soil texture.

Materials Required:

* empty jars and containers full of water
* shovels
* varying soil samples in bags
* plastic sheets (2 m x 2 m)
* rulers, stopwatch, graph paper
* soil auger

Selected References:

Chapter 2, Irrigation Reference Manual: Soil-Plant-Water Relationships International Irrigation Center Modules #2, #3, #4, and #20

Session Topic: Conducting Environmental Assessments

Session Goal: To have Trainees identify all of the factors that need to be considered to conduct simple evaluations of the potential adverse and positive environmental impacts of proposed projects and to apply this information to do an environmental assessment of their own field project.

Session Objectives:

(1) For Trainees to identify the potential environmental problems and benefits that can result from small-scale irrigation projects.

(2) For Trainees to list the environmental parameters that must be assessed in doing simple environmental assessments.

(3) For Trainees to prepare an initial environmental exam form that they can use to assess projects.

(4) For Trainees to conduct a simple initial environmental exam of one of their field projects.

Overview: Irrigation projects have been criticized for creating numerous adverse environmental problems, ranging from disrupting wetland habitats to overloading soils with salts. Most of the environmental problems that result from irrigation developments are the consequence of poor planning or project management. Identifying potential environmental problems before initiating any project activities and putting in place measures that will avoid or mitigate these problems is the only way to guarantee that a proposed project will be socially and ecologically successful. During this session the Trainees will explore the ecological concerns that all irrigation projects should consider and will prepare a form that they can use to quickly and properly evaluate potential impacts.

Session Activities:	
Time	
30 Min.	Trainer presents a diagram of a drainage basin with a small-scale irrigation project as one of many activities occurring in this basin. Trainer then asks Trainees to describe all of the ways in which this irrigation project affects the physical, biological, and social environment in which the project will occur. Trainees should first try to define what they feel is the area being affected by the irrigation project. They should then describe the nature of the impacts that might occur. The trainer should be certain to remind Trainees that impacts can be both positive and negative, if they don't note this themselves. As Trainees describe potential impacts, trainer should record them on a flip chart under category headings of physical, biological, or social.

15 Min.	Trainer presents a brief lecture on the use of environmental assessments to identify potential impacts from projects and incorporate measures that will avoid or mitigate these potential impacts. If available, trainer can review a sample assessment done for an in-country irrigation project with the group, describing the components of the assessment, level of detail used, and applications. Trainer should emphasize that environmental assessments are intended to be part of a project design and thus represent important design information that is to be applied and not simply recorded.
30 Min.	Trainees select someone to facilitate the session, and they are given the task of developing a simple form that they can use to do initial environmental reviews in the field. The form should respect their own skill levels and not necessarily try to mimic the complexity of a full scale environmental assessment. It should, however, include field observations of conditions; professional judgments or calculations, where appropriate; and clear descriptions of measures that will be done to minimize or avoid negative impacts. Trainer can then offer to have their form typed and copied. Trainees are then given a homework assignment to prepare a completed initial environmental review of their field project(s). In completing this assignment, the Trainees should assign specific topic areas to one or two Trainees and then appoint someone to pull all of the diverse information into one report. The final report should be the consensus of the entire group of Trainees.

Trainer Notes: If possible, obtain several completed environmental assessments of small or medium-scale irrigation projects for Trainees to review. This session is best done just prior to the point when Trainees will begin their field work.

Materials Required:

* sample environmental assessments

Selected References:

Chapter 2, Irrigation Reference Manual: Conducting Initial Environmental Evaluations of Irrigation Projects; Illustrative Environmental Review Form

Exam: Section 3 - Field measurements

1. Draw the hydrologic cycle and explain its importance.

2. In doing a watershed inventory, what physical characteristics should be analyzed?

Answer:

soils	vegetation
hydrology	land use
topography	

3. List 3 methods used to measure water flow in a small stream, and describe their installation.

Answer:

bucket/stopwatch method
float/area method
weir method

4. What is the flow rate in cubic feet per second (cfs) of a 6 L/sec flow rate?

Answer: 6 liters per sec. x .0353 cfs/liter per second = .21 cfs

5. On a slope of 1.5%, what is the elevational rise in a horizontal distance of 150 m?

Answer: 1.5/100 = x/150 x = 2.25 m

6. Why is slope such an important concept in irrigation practices and agriculture in general?

7. Using the hand-feel method, determine the texture of the soil sample supplied.

8. How much water might you expect a sandy loam soil to hold between field capacity and wilting point in a one-meter depth?

Answer: = 100-130 mm/m

9. Define: (1) saturation, (2) field capacity, and (3) wilting point.

Answers: Saturation - occurs when all the pore space in a soil is filled with water.

Field capacity - the moisture status of the soil after drainage due to gravity ceases, and the soil retains its maximum amount of water against the force of gravity. This generally occurs 1 to 4 days after saturation.

Wilting point - the point at which water becomes unavailable to the plant; the soil holds on to water tightly.

10. How deep would you normally expect corn roots to go in a soil without hard layers or other obstacles to root penetration? How deep in a soil with a hardpan (hard clay layer) at 30 cm?

Answer:

without obstacles, ≅ 1 meter
with hard pan, ≅ 30 cm

Section 4: Developing water sources

*** Diversion Dams**
*** Designing Spring Boxes**
*** Selecting Pumps**
*** Design and Use of Pump a**
*** Installing, Operating, and Developing Maintenance Plans for Pumps**
*** Wells: Hand Dug and Drilled**
*** Storage Pond Design, Construction, and Management**
*** Exam: Section 4 (Water Supply Estimates and Designs)**

Session Topic: Diversion Dams

Session Goal: Trainees will be able to design and construct small diversion structures.

Session Objectives:

(1) Trainees will be able to select appropriate sites for diversion structures in small stream beds.

(2) Trainees will be able to design small diversion dams using locally available materials.

(3) Trainees will construct a small diversion dam.

Overview: In this session, Trainees will design and construct small diversion dams. All of the building materials will be obtained locally, and the construction will be done in a small stream bed. The purpose of the dam is to raise the water level or create a small reservoir for irrigation. This session should follow introductory sessions on hydrology and tool use.

Session Activities:	
Time	
30 Min.	Trainer asks Trainees to describe factors that need to be considered in designing and constructing dams to divert water for irrigation projects. Discussion should cover types of diversion structures that can be built, dam stability and minimum side slopes, spillway features, sediment control, and appropriate materials that can be used in construction. Trainer informs Trainees that they will now go to the field and construct a diversion. They should identify the tools and materials they will need to complete this job and then assess if these materials are available in the tool supply area. If any tools or materials are lacking, Trainees should get resourceful and determine what local materials can serve as a substitute.
180 Min.	Trainer leads Trainees to the field adjacent to a very small stream. Trainer has Trainees define the criteria they would use to select a site for a diversion structure and then use these criteria for selecting a site in the nearby stream. Trainees divide into groups of four; each group selects a site, assigns work roles, and proceeds to construct a diversion dam in the stream. Trainer concludes session by asking Trainees what could have improved the design or final product. Trainer also asks Trainees how they might have done things differently (or not) if the diversion had been for a larger stream.

Trainer Notes: Ideally, the diversion dam (s) constructed will be able to serve some practical purpose for a local community. If not, then the dam(s) should be removed immediately after the completion of the session.

Materials Required:

* digging bar, hoes, picks, and shovels
* sheets of plastic
* swim suits

References:

Chapter 3, Irrigation Reference Manual International Irrigation Center Module #21

Session Topic: Designing Spring Boxes

Session Goal: Trainees will be able to describe the hydrologic processes that result in springs and design a structure to capture the flow at a spring site.

Session Objectives:

(1) Trainees will be able to describe the tasks involved in spring development.

(2) Trainees will prepare an illustrative spring box design.

Overview: Springs can often represent an important water supply source for irrigation projects. In this session Trainees will learn methods to develop springs, and practice these methods in the field. They will visit completed spring boxes and observe spring hydrology in the field. This session should refer back to basic concepts covered in the watershed hydrology session.

Session Activities:	
Time	

60 Min.	Trainer brings Trainees to two spring sites in the field: the first should be an undeveloped spring that is flowing; the second should be a developed spring with completed, functioning spring box. At the undeveloped spring site, trainer should have Trainees describe the basic ground water hydrology that resulted in this spring source. Trainees should perform a simple flow measurement of the spring and identify any difficulties in determining the total flow, especially if the spring does not flow uniformly from a single outlet point. Trainees should describe the process they would follow to develop this source.
45 Min.	Trainer then leads group to developed spring site and has Trainees determine what steps were apparently followed in completing the spring development. Trainees should compare the process followed at the developed site with the process they described at the undeveloped site. Trainer distributes copies of diagrams that demonstrate procedures for constructing spring boxes, and Trainees compare diagrams with actual construction at the developed site.
45 Min.	Trainees return to undeveloped spring site and are instructed to collect data necessary to prepare a complete spring box design at the site. (If the distance between the undeveloped and developed site is great, then this data collection exercise should be done prior to leaving the undeveloped site.) Trainer divides the Trainees into groups of three and instructs each group to complete a spring box design as a homework assignment with 4-day due date. The design should include a complete materials list for the type and quantity of materials to be used in building the spring box. Trainee groups should work independently on this exercise.
30 Min.	After Trainee groups turn in their spring box designs, trainer facilitates session in which they compare the designs produced and resolve any outstanding questions or concerns about completing the actual construction of the design in the field.

Trainer Notes: If time permits, it is recommended that Trainees actually proceed to build their spring box. Building a spring box, however, is a time consuming effort, which unfortunately could detract from other essential sessions in the irrigation training. It may be necessary to limit the effort to this simple theoretical exercise.

Materials Required:

* bucket, cup, funnel
* tape measure
* stopwatch
* spring box design procedures handouts

References:

Chapter 3, Irrigation Reference Manual: Structures for Springs and Seeps

Session Topic: Selecting Pumps

Session Goal: Trainees will be able to describe different kinds of pumps available and the factors that influence pump selection.

Session Objectives:

(1) Trainees will be able to describe the different types of pumps available - human, animal, mechanical - and their applicability.

(2) The Trainees will demonstrate an understanding of basic hydraulics that affect the selection and design of pumps.

(3) Trainees will identify the types of pumps suitable for local conditions.

Overview: A familiarity with pumps and their applicability is required for the Volunteer to design systems that lift or pressurize water. This session will strengthen some of the material covered briefly in the session on wells and will supplement material to be presented in sessions on farm water delivery systems.

Session Activities:	
Time	
45 Min.	Trainer will present and describe various types of pumps that are used locally or regionally in well development or irrigation projects. Include in this discussion a description of the concepts of pressure, lift, flow rate, pumping conditions encountered (rivers, wells, reservoirs, canals), typical purchase costs, and how these factors influence decisions about pump selection. If time permits, trainer can have Trainees disassemble and reassemble one or more of the pumps, making certain that they record the procedures that they followed.
30 Min.	Trainees will list criteria that must be considered for pump selection, and trainer will provide basic data to enable Trainees to calculate total dynamic head and flow rates and perform pump selections. Trainees will identify factors that could constrain a quantitative selection of pumps. Trainees will determine those pumps that are most appropriate for local conditions.
45 Min.	Trainees will visit pumping plants in the field and describe the components in detail.

Trainer Notes: Trainees should have an opportunity to identify and work with a variety of pumping plants in the field. Providing Trainees with an opportunity to inspect or actually disassemble a pump would add a great deal to the value of this session. If time does permit disassembly and reassembly of a pump, it is recommended that trainers limit the number of tools available to do this job in order to simulate typical site conditions.

Materials Required:

* centrifugal pump, hand pump, suction pump
* tools for disassembly
* transport to field

References:

Chapter 3, Irrigation Reference Manual: Pumps and Water Lifting Devices

Session Topic: Design and Use of Pumps

Session Goal: Trainees will be able to develop the specifications for small irrigation pumps required by the pump supplier and installer.

Session Objectives:

(1) The Trainees will be able to develop the specifications for a mechanically driven centrifugal pump - total dynamic head, flow rate, horsepower requirements, transmission devices, prime movers (electric or internal combustion), and intake structures.

Overview: Pumps powered by small engines or electric motors are commonly used by small-scale farmers to obtain water from streams and wells. The irrigation technician, pump supplier, and installer must be familiar with the concepts of pump design and use if the correct pump specifications are to be developed. This session is intended to follow an earlier session on pump selection.

Session Activities:	
Time	

45 Min.	Trainer will briefly review the material discussed in the Pump Selection section and then ask Trainees to identify factors that specify the characteristics of a pumping station, e.g., flow rate, horsepower, pressure, lift, total dynamic head, and cavitation. Trainer will then work out a sample problem to demonstrate to Trainees how these factors are calculated and accounted for. Trainer provides sample problems for the Trainees to solve.
90 Min.	Trainees will interview a local pump supplier to determine the types of pumps available and the technical information that exists or is lacking to support pump design and selection procedures.
45 Min.	Trainees will travel to the field where they will collect the data necessary to determine the appropriate pump for a specific location. They will then use these data to design the specifications for a pump station.
90 Min.	Trainees will then travel to another nearby field site where a pump is to be installed. They should apply the basic skills learned to determine whether the location, intake structures, and general conditions are appropriate for the pump selected. If possible, Trainees should participate in or conduct the pump installation.

Trainer Notes: Trainer should locate an installed pump that can be visually observed during operation by the Trainees, a pump supplier representative of typical Volunteer site accessibility, and a site where a pump is planned for installation.

Materials Required:

* Abney level
* pressure gauge
* surveying rod
* tape measure

References:

Chapter 3, Irrigation Reference Manual: Pumps and Water Lifting Devices; Wells

Session Topic: Installing, Operating, and Developing Maintenance Plans for Pumps

Session Goal: Trainees will be able to properly install, operate, and perform maintenance procedures on a pumping plant.

Session Objectives:

(1) The Trainees will participate in exercises that enable them to evaluate the installation, operation, and maintenance of a pumping plant.

Overview: Proper installation, operation, and maintenance procedures are essential to ensure that a pump maintains its capacity to perform efficiently over time. This session should immediately follow the two previous sessions in pump selection and design.

Session Activities:	
Time	

45 Min.	Trainees are divided into three groups. One group is assigned the task of describing the procedures necessary to correctly install a pump, a second group describes the procedures to operate pumps, and the third group describes pump maintenance. Groups reconvene after 10-15 minutes and make a presentation of their ideas to the full group. Trainer works with this information to instruct Trainees in common techniques for evaluating pump performance (pressure and flow rate). Trainees describe how this information can be integrated with the information from the previous pumping sessions and applied in a comprehensive process as part of an overall irrigation system design.
75 Min.	Trainees travel to the field where they evaluate a pump for flow rate, pressure, general condition, transmission devices, and motors or engines. As a group, Trainees develop recommendations on how to improve operation and maintenance for this pumping plant.

Trainer Notes: Pumps often do not perform as they should due to poor selection, installation, or maintenance. Thus, it is important for Trainees to evaluate a pumping plant that is not necessarily perfect and in which recommendations for improvement will be valid.

Materials Required:

* flow measuring device
* pressure gauge and fittings to install on pump discharge
* tape measure

References:

Chapter 3, Irrigation Reference Manual: Pumps and Water Lifting Devices; Wells

Session Topic: Wells: Hand Dug and Drilled

Session Goal: Trainees will be able to select a suitable well site, rehabilitate a well, and facilitate well development.

Session Objectives:

(1) Trainees will identify factors that determine a suitable well site according to the type of well being considered.

(2) Trainees will describe the construction steps necessary for a shallow hand dug well and a drilled well.

(3) Trainees will describe practices used to protect wells.

(4) Trainees will rehabilitate a well in the field.

Overview: Wells can represent an important water supply source for irrigation. As Volunteers, Trainees may have access to both drilling facilities or labor to dig shallow wells. This session provides Trainees with sufficient background information to plan and guide well development. This session should be done after Trainees have had some exposure to basic hydrology concepts.

Session Activities:	
Time	

90 Min.	Trainer presents a diagram of the hydrologic cycle, with some delineation of geologic formations. Trainees are asked to indicate suitable locations for wells that could tap the water stored in these formations. Trainer should use this exercise to explain the types of wells available and the general steps followed in constructing a simple hand dug well and a drilled rotary well. It will be important to use many graphical depiction's of the steps followed in well development. Trainees are asked to list the kinds of problems they might anticipate in digging or drilling a well and maintaining the well after it is in operation. Trainer concludes with a description of the procedures used to disinfect wells and protect wells from contamination if they are for household use as well as irrigation purposes.
90 Min.	Trainees travel to the site of a well that is no longer in use or simply in need of repair. Trainees will interview owner(s) of the well and learn the history of the well's development and maintenance. Trainees describe the steps that were apparently followed to design and construct the well and indicate measures that might have improved the process. Trainees will inspect the well and determine the need for well rehabilitation: improved well protection, well disinfection, pump repair, or repair of lining.
2-4 Hr.	Trainees rehabilitate the well, completing all of the tasks they identified as necessary in their well inspection.
45 Min.	Trainees meet with well owner(s) and provide them with information to guide their future use and management of the well.
3-4 Hrs.	Trainees visit the site of a drilled well in the drilling stage. Trainees observe the drilling process, describe the steps that were apparently followed in developing the well, and interview the drillers.

Trainer Notes: It is advisable to select a well for rehabilitation that does not require a great deal of effort. Simple hand pump repair and disinfection of the well may be enough to fill out this exercise. If pump repair will be a part of the session activities, then this session should follow the sessions on pumps in the Developing Water Sources section of this manual. While it would be ideal for Trainees to actually construct their own hand dug well, this would consume from 3-5 days in the training and may demand too much time. Trainers need to identify some well projects under construction for the Trainees to visit during this session.

Materials Required:

* chlorine
* rope
* transport
* wrenches, pliers, vice grips, and screwdrivers

References:

Chapter 3, Irrigation Reference Manual: Pumps and Water Lifting Devices; Wells

Brush, R.E. 1982. Wells Construction: Hand Dug and Hand Drilled. Peace Corps Information Collection and Exchange Manual M-9. 282p.

Peace Corps. 1984. Rural Water/Sanitation Projects: Water for the World. Peace Corps Information Collection and Exchange. pp. 107-142.

Session Topic: Storage Pond Design, Construction, and Management

Session Goal: Trainees will be able to list site criteria for pond construction and design and construct a small storage pond.

Session Objectives:

(1) Trainees will identify the appropriate type of storage pond for specific water sources and topographical conditions.

(2) Trainees will conduct a rapid site survey to determine basic pond construction requirements.

(3) Trainees will design earth embankments.

(4) Trainees will construct a small storage pond appropriate to the site conditions.

Overview: Storage ponds are becoming more important in agriculture as competition for use of water sources increases, watershed conditions decline, and seasonal variability of supplies increases. Well designed ponds can supplement plant water needs during periods of low water flow or sporadic rainfall, and they can stabilize or regulate flows. This session provides Trainees with adequate skills to design and construct a small pond.

Session Activities:	
Time	
60 Min.	Trainer introduces session with brief lecture on the role of ponds in irrigation systems, the types of ponds that can be used (on or off-stream), and the criteria used to select a pond site and estimate pond size. Trainer then presents a graphic example of how earth embankment design is done to stabilize ponds. Trainees are asked as a group how they would organize all of this information to enable them to conduct a rapid field inventory of potential pond sites.
75 Min.	Trainees are divided into groups of three and instructed to go into the field to conduct a rapid survey to locate potential pond sites. After identifying the sites, Trainees should come back together as a group and mutually select the most preferred pond site location. The group process that occurs in this endeavor can be as valuable as the pond construction, and the Trainees should be encouraged to describe the reasoning behind their selection.
6-8 Hr.	Trainees should work as a team to design and construct a small pond. After completing the pond, Trainees should divert water from the stream source and fill the pond. Filling the pond will take some time, and the Trainees can assign a small group to supervise this process. After 1-3 days, the Trainees should return to determine how well the pond is holding up and how much water is being lost through seepage.

Trainer Notes: It is advisable to plan this endeavor with a local community so that they can use the pond after it is completed.

Materials Required:

* hand or Abney level
* large sacks for hauling soil
* manual tampers
* PVC tube (diameter depends on source flow rate)
* sheets of plastic (if soil is very permeable)
* shovels, picks, and hoes
* stakes
* stopwatch
* surveying rod
* tape measure
* wheelbarrow
* 5-gallon bucket

References:

Chapter 3, Irrigation Reference Manual: Ponds for Irrigation Water Storage

Exam: Section 4 - Developing water sources

1. List different types of material that can be used to construct a diversion.

Answer:

earth	sand bags
rocks	gabions
logs	concrete

2. Describe what a gabion is and explain how it can be used in diversion dams.

Answer:

A gabion is a basket made of heavy-duty wire mesh, placed in the stream bed, and filled with rock. It is used as a building block in construction of diversions.

3. Describe the sequential steps in developing a spring source.

Answer:

1. Locate the origin of the flow.
2. Dig large hole.
3. Measure the flow from the spring.
4. Fill in the hole with gravel or rocks to protect spring.
5. Dig diversion ditch above spring.

4. Explain the situations in which you would consider a hand-dug well for irrigation; a commercially drilled well.

Answer:

Hand-dug - Shallow water table, low flow rate required, labor is cheap and available.

Drilled - Deep water tables, hard formations such as rock, larger flow rates required, availability of equipment or commercial well drillers.

5. A farmer comes to you and asks for advice on a secondhand, 5 HP, centrifugal pump that he has just bought. He wants to sprinkler irrigate a 0.5 hectare plot but knows nothing about the pump capacity. What factors must be taken into consideration?

Answers:

1. What flow rate is required?
2. What head is required?
3. Does the pump have adequate flow and head capacity?

6. Describe the equation needed to calculate total dynamic head in a pumping system. (Assume velocity head is negligible.)

Answer:

$tdh = h_z + h_p + h_f$

h_z = elevation head (vertical distance pump must raise water)
h_p = pressure head (pressure required to operate the sprinkler system, drip system, etc.)

h_f = friction head (pressure losses due to flow through pipe)

7. List the general specifications that you should provide a pump supplier when selecting a pump.

- amount of water to be pumped
- pumping head
- horsepower requirements
- operating efficiency
- type of prime mover and transmission device

8. In a communal system, a farmer is given water 6 hrs/day at a flow rate of 100 L/min. a) If the farmer irrigates every 3 days, how large of a storage pond must he construct to store the water? b) If, at peak use, his crops need 5 cm of water per week, which he will apply through a sprinkler system, how much land can he irrigate with the pond? (No water on Saturdays.)

Answer:

a) Volume = Q x T = 100 L/min x 6 hrs/day x 3 days x 1 m^3/1000 L x 60 min/hr = 108 m^3. The pond can have an average surface area of 100 m and be 1.1 m in depth. However, a freeboard is generally needed. Thus, add 0.3 meters of required freeboard. Pond should be 10 m x 10 m x
1.4 m.

b) He will apply 2.5 cm, or 0.025 m twice a week. Area = volume/depth = 108 m^3/.025 m = 4320 m^2

Section 5: Assessing irrigation water requirements

*** Estimating Net Crop Water Needs**
*** Estimating the Efficiency of Irrigation Systems**
*** Estimating Gross Daily Irrigation Requirements and Design Capacity**
*** Exam: Section 5 (Calculating Water Requirements)**

Session Topic: Estimating Net Crop Water Needs

Session Goal: Trainees will be able to estimate net crop water requirements using local crop data.

Session Objectives:

(1) Trainees will be able to define crop water use and the factors that determine the crop water deficits that are compensater for through irrigation.

(2) Trainees will be able to estimate net irrigation requirements using local crop and climate data.

Overview: Estimating net irrigation requirements is an essential prerequisite for the design and management of farm irrigation systems. Trainees will now apply skills learned in estimating water supplies and evaluating soil conditions to determine how much water must be made available to support specific crops.

Session Activities:	
Time	
60 Min.	Trainer will begin session by describing several crops and then ask Trainees to describe the factors that determine how much water is needed to support these crops. Trainer should list these factors on a flip chart and then begin a brief lecture that links the factors identified by the Trainees to the concepts of evapotranspiration, reference crop evapotranspiration, crop coefficients, dependable and effective rainfall, ground water contribution, and soil water storage. Trainer should be able to describe each of these concepts graphically, assigning mathematical symbols for each concept.

60 Min.	Trainer then uses one or two basic examples to demonstrate the use of equations and simple techniques for quantifying evapotranspiration, effective rainfall, and net irrigation requirements. Next, trainer pins up local crop, temperature, and rainfall data, and assigns each Trainee two or three specific crops. Trainees are to use the local data to estimate the net irrigation requirements for each crop. Trainees compare results at the conclusion of the exercise, and trainer describes the role of estimating net crop water needs in planning an irrigation system design.

Trainer Notes: Trainers need to obtain local data before the session. Climatic data should be available from government or university sources. Crop data may be scarce, and it may be necessary for the trainers to assemble this information from their own field observations and professional experience.

Materials Required:

* calculator
* local data on crop types, length of growing season, crop development stages
* local data on maximum and minimum temperatures, monthly rainfall

Selected References:

Chapter 4, Irrigation Reference Manual: Estimating Irrigation Requirements International Irrigation Center Modules #7, #8, and #9

Session Topic: Estimating the Efficiency of Irrigation Systems

Session Goal: Trainees will be able to estimate how efficiently water is being conveyed and applied to fields.

Session Objectives:

(1) Trainees will be able to define application and conveyance efficiencies and list the factors that determine the efficiency of an irrigation system.

(2) Trainees will be able to estimate the expected irrigation efficiency as a function of irrigation method used.

(3) Trainees will be able to estimate conveyance efficiencies as a function of soil type and canal conditions.

Overview: Irrigation efficiencies must be estimated correctly if crop water needs are to be met by the irrigation system. Thus it is important that Trainees be able to estimate efficiency with some accuracy. This session represents a good linkage with the session on estimating crop water requirements to begin to show how to estimate total project water needs.

Session Activities:	
Time	
45 Min.	Trainer begins session with a profile drawing of an irrigation canal and irrigated field and an inflow of water on one end. Be certain to include some plants and debris in the drawing alongside the canal. Trainer asks Trainees to describe all of the ways water moves through this profile, adding to the drawing the concepts of infiltration, soil water movement, and evapotranspiration. Trainer describes the goal of irrigation as supplying limited water supplies to the greatest possible area for crop cultivation. Trainees then list all of the factors that must be taken into account to determine how efficiently water is being moved through conveyance channels and onto fields. Trainer then links this description of factors to concepts in simple equations that can be used to estimate canal and field efficiencies. Trainer uses one or two simple examples to show how these efficiencies are calculated.

75 Min.	Trainer leads Trainees into the field and instructs groups of three to record visual observations of soils, irrigation method, and canal conditions. Each group should then estimate canal and field application efficiencies.

Trainer Notes: Trainer may want to have Trainees measure inflow and outflows from a canal if time permits and if Trainees have already had sessions enabling them to do this calculation. Measuring flows will give them practice in measuring conveyance efficiencies.

Materials Required:

* calculator
* flow measurement equipment if efficiencies are to be measured
* note pad
* transport

Selected References:

Chapter 4, Irrigation Reference Manual: Estimating Irrigation Requirements
International Irrigation Center Modules #29, #30, and #31

Session Topic: Estimating Gross Daily Irrigation Requirements and Design Capacity

Session Goal: Trainees will be able to estimate daily irrigation requirements as a depth of water to be applied and use this information to determine the amount of water required to support an irrigation system.

Session Objectives:

(1) Trainees will be able to calculate the gross daily irrigation requirements for a system as a depth of water to be applied and as a flow rate required.

Overview: The gross water requirements of an irrigation system must be known before we can determine whether the available water supply is sufficient to meet the crop needs. This information is necessary to estimate canal and pipeline design capacities and effectively manage an overall irrigation system. This session builds on the experiences Trainees have had in the previous sessions on estimating net crop water requirements and estimating canal and field efficiencies.

Session Activities:	
Time	
45 Min.	Trainer provides some basic data about a proposed irrigation system: flow rate from an available stream, estimated crop water requirements, dimensions and materials for conveyance channels, and annual monthly rainfall. Trainer asks Trainees if they feel they have enough information here to design and manage the system. If not, Trainees should identify additional information they feel is necessary to facilitate a system design. Trainer records this information and uses it to derive equations that can be used to estimate gross water requirements, emphasizing estimates of both water depth and flow rates to meet the system needs. Trainees use the same data as were distributed in the sessions on estimating net crop water requirements and estimating canal and field efficiencies to calculate the gross depth of water required to satisfy a given local crop and the design flow rate required on a per area basis.

Trainer Notes: This session should immediately follow and build on the previous session plans in this section so that the concepts tie together easily.

Materials Required:

* calculator
* local climatic and crop data
* results from previous sessions

References:

Chapter 4, Irrigation Reference Manual: Estimating Irrigation Requirements
International Irrigation Center Modules #38, #39, and #40

Exam: Section 5 - Calculating water requirements

1. List 5 factors that you must quantify in order to determine the design capacity of an irrigation system.

Answer:

Crop water use
Effective rainfall
Irrigation efficiencies
Hours per day of operation
Area to be irrigated

2. In February, at a station with a latitude of 14°N, daily maximum average temperatures are 28°C and average daily minimum temperatures are at 15°C. What ETo might you expect?

Answer:

Ra = 13.6 mm/day (from Table 4.1, Irrigation Reference Manual), Td = 28 - 15 = 13°C
T° C = 1/2(28 + 15) = 21.5
$ETo = 0.0023 \times Ra \times Td^{1/2} \times (T° C + 17.8) = 0.0023 \times 13.6 \times 13^{1/2} \times (21.5 + 17.8) = 4.43$ mm/day

3. With low wind and high humidity conditions, what maximum Kc might you expect for a lettuce crop at mid-season?

Answer:

Kc is approximately that of cabbage and equals
0.95 for low advective conditions (from Table 4.3, Irrigation Reference Manual).

4. What ETc might you expect at mid-season for the conditions of Problems 2 and 3?

Answer:

$ETc = Kc \times ETo = 0.95 \times 4.43 = 4.2$

5. What ETc might you expect initially in the season for the lettuce crop if ETo is 5 mm per day?

Answer:

$ETc = 0.4 \times 5.0 = 2.0$ mm/day

6. If your mean rainfall is 50 mm for February and is 80% effective, what is the average monthly effective rainfall (Pe) in mm/month? mm/day?

Answer:

Pe = Pmean x effectiveness	= 50 mm x 0.8 = 40 mm/month

	= 40/28 = 1.4 mm/day

7. What is the net daily water requirement (Ire) with the ETc of Problem 4 and the Pe of Problem 6? Assume Wb and Gw = 0.

Answer:

Irn = ETc - Pe = 4.2 - 1.4 = 2.8 mm/day

8. What is the gross daily irrigation requirement (Irg) for the example of Problem 7 if the efficiency of application is 70% and the conveyance efficiency is 80%?

Answer:

Irg = Irn / Ea x Ec = 2.8 / 0.7 x 0.8= 5.0 mm/day

9. What is the design capacity, using Irg of Problem 8, of a system that will operate 12 hours per day every day on a 2-hectare plot?

Answer:

Q = 2.8 x A x Irq / t= 2,8 x 2 x 5.0 / 12= 2.3 L/sec

Section 6: Farm water delivery systems

*** Components of Farm Irrigation Systems**
*** Canal Design, Construction, and Maintenance**
*** Control Structures: Cheeks, Diversions, and Drops**
*** Pipe System Design, Construction, and Maintenance**
*** Land Leveling or Smoothing**
*** Surface Irrigation Systems**
*** Surface Irrigation Systems: Border Systems**
*** Surface Irrigation Systems: Furrow Systems**
*** Sprinkler Systems**
*** Localized Systems**
*** Exam: Section 6 (Designing System Requirements)**

Session Topic: Components of Farm Irrigation Systems

Session Goal: Trainees will be able to describe the components of an irrigation system and explain their function.

Objectives:

(1) Trainees will visit several different irrigation projects and identify the components that make up an irrigation system.

(2) Trainees will describe the function of the components in an irrigation system and describe how this information is important in planning projects.

Overview: To familiarize Trainees in cultural practices of irrigation, they should see the components to understand fully how and why the system operates. Trainees should visit several different types of irrigation projects and discuss how each component is an integral part of the system.

Session Activities:	
Time	

2-3 Hr.	Trainer leads Trainees on walking tour of irrigation projects in the training area. Trainees are told to describe and record the various components of the irrigation systems they are observing (e.g., water supply source, water conveyance methods used, quality of water in the conveyances, farm water application practices, crops being grown, field drainage practices) and to try to develop some assumptions about the reasons for the system designs. Trainees should begin their system review at the water source and end at a farm drainage canal.
60 Min.	Trainees gather at a convenient point and use their observations to label specific components of farm water systems and establish clear descriptions of the features and factors included in each component.

Materials:

* transport

References

Chapter 5, Irrigation Reference Manual: Components of Farm Irrigation Systems

International Irrigation Center Modules #21, #22, #23, #24, #25, #26, and #27

Session Topic: Canal Design, Construction, and Maintenance

Session Goal: Trainees will be able to design and construct simple distribution canals and perform general canal maintenance practices.

Objectives:

(1) Trainees will demonstrate the ability to complete canal design requirements.

(2) Trainees will be able to use the Manning equation to properly design trapezoidal canals and use nomographs to assist in the calculations.

(3) Trainees will design and construct a small canal for a water distribution system.

(4) Trainees will tour an existing water distribution system and identify practices necessary to maintain an efficient system.

(5) Trainees will perform maintenance practices in a canal.

Overview: Canal conveyance systems are a main component in getting water from the source to the field. Trainees will be taught how to properly size a canal to carry a given flow rate and learn construction techniques. This session also enables Trainees to apply many of the concepts they learned in the earlier hydrology and developing water resources session.

Session Activities:	
Time	
90 Min.	Trainer presents a profile drawing of an irrigation canal. Trainer asks Trainees to identify the factors that must be taken into account when designing this canal. Trainer uses Trainee information to present brief lecture on canal design criteria and requirements. Included in the lecture should be an explanation of the Manning equation, using diagrams to describe the origin of each factor in the equation. Lecture should also include sample problems showing how the Manning equation is used and how to use nomographs. Present and discuss the continuity equation and its use in canal design.

30 Min.	Trainer provides Trainees with some hypothetical data and instructs them to perform independently the calculations necessary to size a canal.
90 Min.	Trainer leads Trainees to the field, where they are instructed to collect the data necessary to design and construct a small canal. Trainer indicates approximate location of canal and requests to review the completed canal design with 90 Min. Trainees are left on their own to determine roles and responsibilities.
2-5 Hr.	Trainees clear brush, stake out route at desired slope, dig the canal, and install a sediment trap. Again, Trainees are left on their own to determine roles and responsibilities in completing this construction work.
45 Min.	Trainees divert and run water into the canal, checking the side slope stability and water velocity. Trainer reviews Trainee work and facilitates discussion of problems and important learning that occurred.
2-4 Hr.	Trainer leads Trainees to tour an existing canal distribution system and asks them to comment on condition of the canal and recommend necessary maintenance practices. Trainees should measure the flow rate in the canal and then perform the necessary tasks to complete a canal maintenance exercise. After completing the canal maintenance, Trainees should again measure the flow rate and evaluate improvements made by canal maintenance.

Materials

* bucket
* calculators
* hoes, rakes, shovels, picks, machetes
* leveling device
* measuring tape
* stakes
* stopwatch
* surveying rod

References:

Chapter 5, Irrigation Reference Manual: Control Structures

Session Topic: Control Structures, Checks, Diversions, and Drops

Session Goal: Trainees will identify the factors involved in selecting and applying the use of control structures in a canal system, design simple checks, diversions, and drops, and be able to construct and install them.

Objectives:

(1) Trainees will list different types of control structures and describe their function in a canal system.

(2) Trainees will be able to design, construct, and install simple control structures in a canal system.

(3) Trainees will be able to demonstrate the use of a canvas and pole as a check structure in a canal.

Overview: Often earthen canal systems are inefficient because water is not controlled properly in the canal. This results in erosion and washouts. Control structures limit flow velocities to permissible rates so that this does not occur. This session builds on canal design and construction and will give Trainees more flexibility in routing canals through irregular and sloped topography and make water distribution easier and more efficient from the conveyance canal to the field.

Session Activities:	
Time	

60 Min.	Trainer asks Trainees to describe simple structures they can build to control flow in a canal. Trainer uses this list to diagram types of structures available and their functions. Diagrams should indicate design criteria.
90 Min.	Trainees go to the field where they collect the necessary data and prepare to construct a wooden or concrete control structure in a canal. Preparation should include gathering materials and bringing them to the construction site.
2-3 Hr.	Wooden or concrete control structure should be constructed and installed. Trainer will critique the installation.
60 Min.	After several days, Trainees should return and remove the forms for the structure, and send water through the canal. The operation of all control structures should be checked to determine if there are any washouts or rocks at the downstream side of the drop (energy dissipaters). The water velocities in the canal should be measured. Trainer can conclude exercise with discussion of the importance and applications of control structures.
60 Min.	Have Trainees construct a canvas check dam and install it in a farm irrigation ditch to adjust the water in the canal to a level that will permit distribution onto a field.

Materials:

* 1.5 m poles
* buckets
* canvas or sheets of plastic
* cement
* gravel
* hammers, saws
* hoes, machetes, picks, shovels
* rails
* sacks (haul gravel/sand)
* sand
* stopwatch
* tape measure
* wood planks/lumber

References:

Chapter 5, Irrigation Reference Manual: Control Structures International Irrigation Center Module #21

Session Topic: Pipe System Design, Construction, and Maintenance

Session Goal: Trainees will be able to size tubing correctly for pressurized systems, describe basic hydraulic phenomena that commonly occur in pipelines, and list the criteria for pipeline installation.

Session Objectives:

(1) Trainees will be able to describe the term "pressure head" in units commonly used in irrigation, e.g., psi, kg/cm^2, feet, and meters.

(2) Trainees will be able to calculate frictional losses in a pressurized pipeline and determine proper pipe sizing for a given pressure head.

(3) Trainees will be able to describe certain hydraulic principles in pressurized pipe systems (i.e. water hammer, air relief, pressure relief) and ways in which they can be controlled or reduced.

(4) Trainees will be able to list different types of piping material and describe their use and specifications.

(5) Trainees will be able to describe pipeline installation criteria.

Overview: This session is the basis for the design of pressurized irrigation systems. Proper main line design and installation will assure an adequate operating pressure at the sprinkler nozzles or drippers. Trainees will learn methods to calculate frictional loss in pipelines and installation practices to assure adequate and trouble-free operation.

Session Activities:	
Time	
90 Min.	Trainer demonstrates concept of pressure head by elevating a five-gallon bucket filled with water to a height of two meters, and siphoning from the bucket. Check the head in the tube at lengths of 5 and 10 meters and the outflow from the hose. Now elevate the bucket to a height of five meters and do the same thing. Trainer uses this demonstration to lead into lecture on basic principles of hydraulics, emphasizing the concepts of pressure head, friction, and energy.
60 Min.	Trainer presents brief overview of equations used to calculate friction losses in pipes and the cost per unit length of various sizes and types of pipe, demonstrating how this information is used to select pipe sizes. Trainees are provided with sample data and instructed to select proper pipe sizes for a hypothetical system. The design should emphasize selection of pipeline components and materials to avoid unacceptable pressure losses and ensure adequate flow while accounting for economic considerations. Trainer concludes exercise with overview of the concept of water hammer and techniques for identifying potential water hammer problems in the field.
60 Min.	Trainer reviews techniques used to control pipe pressures and describes mechanisms for siting relief valves. Trainer brings out sample pipe materials to describe the varieties of pipe types and pressure ranges available and to demonstrate installation procedures and criteria.

Trainer Notes: This session can appear to be very complicated to Trainees with limited or no background in hydraulics. Trainers should be prepared to use diagrams and drawings wherever possible to relate the concepts to real situations and to use pipe materials to show how these concepts are applied.

Materials Required:

* 2 1/2" diameter tees
* 5-gallon bucket
* bucket
* rope
* 30 meters of 1/2" diameter polyethylene tube (one 20-meter length and two 5-meter lengths)
* calculator
* stopwatch

References:

Chapter 5, Irrigation Reference Manual: Pipeline Hydraulics and Design

Session Topic: Land Leveling or Smoothing

Session Goal: Trainees will be able to identify and analyze land leveling needs and perform a land smoothing exercise with a low-input implement to move soil.

Session Objectives:

(1) Trainees will be able to identify land leveling needs.

(2) Trainees will be able to describe construction criteria and constraints in land leveling.

(3) Trainees will describe low-input implements used in land smoothing.

(4) Trainees will perform a land survey and smoothing exercise.

(5) Trainees will construct a land smoothing implement (wooden buck scraper).

Overview: Land leveling is an important practice to establish a level land grade so that surface water advances and is distributed uniformly. Often this is not practical in small-scale operations because of the large investment to move soil. Therefore, land smoothing is preferable for small farmers. This session builds on previous sessions on surveying and soils and will allow Trainees the opportunity to work with implements powered by animal traction. This session will also be useful in the following session on border irrigation practice.

Session Activities:	
Time	
60 Min.	Trainer shows Trainees drawings or slides of fields that have not been well leveled and asks Trainees to identify techniques that can be used to improve water distribution in the field. Trainer uses this information to define the concept of land leveling and its application in surface irrigation. Descriptions of land leveling limitations and practical techniques are included.
120 Min.	Trainees use trainer diagram to construct a land smoothing implement (buck scraper is recommended). Trainees should be allowed to determine work roles and responsibilities in completing this task.
60 Min.	Trainees should observe the spread of water over a field and determine the variation in depth of water due to unevenness of the field. This exercise will help them see the extent of leveling required. A plow and buck scraper can be used to move soil from high to low areas when the field dries out, thus making the soil surface more even.
60 Min.	If time permits, Trainees may construct a graded border with no cross slope as follows. Trainees complete a survey of a field and lay out the contour lines at a very slight slope (0.5-1 percent). The spacing of the contour lines will depend on the depth of soil and the desired width of the border. Generally, border width will vary from 3 meters to 10 meters, depending on the convenience of operating machinery in the border and avoiding excessive topsoil removal.
120 Min.	Trainees should plow between their guide markers and then use their land smoothing implement to smooth and level between contour lines.
30 Min.	Trainer can conclude by asking Trainees to describe time management skills they will need to develop in order to factor in all of the varied activities necessary in developing a farm irrigation system.

Trainer Notes: If Trainees have very little experience in working with farm animals, it may be advisable to have a local farmer help them with this exercise.

Materials Required:

* leveling device (e.g. water level)
* lumber
* nails
* nuts and bolts
* plow implement
* saws, hammers
* shovels, hoes
* stakes
* steel chain
* team of oxen

References:

Chapter 5, Irrigation Reference Manual: Land Leveling

Session Topic: Surface Irrigation Systems

Session Goal: Trainees will be familiar with the different types of surface irrigation methods and be able to describe basic criteria for their selection and design.

Session Objectives:

(1) Trainees will be able to list the different types of irrigation methods and give a brief explanation of each.

(2) Trainees will be able to describe the appropriateness and adaptability of each irrigation method in relation to specific land and crop conditions.

(3) Trainees will be able to list the advantages and disadvantages of each method in relation to local conditions.

(4) Trainees will be able to describe basic design criteria for surface systems.

Overview: This session is used to introduce and discuss different types of surface irrigation and their adaptability to agricultural conditions. Specific terms will be defined and basic design criteria for systems should be presented.

Session Activities:	
Time	
45 Min.	Trainer asks Trainees to describe the types of methods that can be used to divert water from a canal and irrigate a field. Trainer should use this information to establish different surface practices (e.g. flood, furrow). Trainees are asked to describe the advantages and disadvantages of each system and identify criteria that must be used in designing each system.
30 Min.	Trainees are divided into groups of three with each group assigned a particular surface irrigation method. Trainer provides each group with basic data and the group is instructed to complete a simple system design.

Trainer Notes: This session can be supplemented through use of slides or videos.

Materials Required: none

References:

Chapter 5, Irrigation Reference Manual: Surface Irrigation Systems

International Irrigation Center Modules #22, #23, #24, and #27

Session Topic: Surface Irrigation Systems: Border Systems

Session Goal: Trainees will be able to design, install, and operate a border irrigation system.

Session Objectives:

(1) Trainees will demonstrate skills to design a small border irrigation system.

(2) Trainees will demonstrate skills to lay out and construct a border irrigation system.

(3) Trainees will demonstrate skills to operate border irrigation system.

Overview: In this session, Trainees will develop a border irrigation system from design to operation. It will give them confidence to complete future projects. The session builds on canal design, conveyance systems, and land leveling sessions. It is recommended that the field for the irrigation system be the same field where the land leveling session took place.

Session Activities:	
Time	
60 Min.	Trainer reviews data requirements, design criteria, and construction techniques for a border irrigation system. Trainees are instructed to collect the necessary data and construct a border system in a designated field.
90 Min.	Trainees collect necessary data on topography, soils, and crops, and complete system design.
4-6 Hr.	Trainees construct a conveyance system to bring water to the field, lay out and construct the borders, and construct the tail water ditch.
2-3 Hr.	Trainees will plant crops in the borders, irrigate the field, and check the borders for stability.

Trainer Notes: This exercise can be done with a local farmer to make the end result very practical.

Materials Required:

* crop ready to be planted
* leveling device, survey rod, stakes
* sheet of plastic
* shovels, picks, hoes
* soil auger
* tape measure
* two poles 1.5 m

References:

Chapter 5, Irrigation Reference Manual: Surface Irrigation Systems

International Irrigation Center Module #24

Session Topic: Surface Irrigation Systems: Furrow Systems

Session Goal: Trainees will be able to design, install, and operate a furrow irrigation system.

Session Objectives:

(1) Trainees will demonstrate skills to design a furrow irrigation system.

(2) Trainees will demonstrate skills to lay out and install a furrow irrigation system.

(3) Trainees will demonstrate skills to operate and manage a furrow irrigation system.

Overview: In this session, Trainees will develop a furrow irrigation system from design to operation. It will give them confidence to complete and be involved in future projects. This session builds upon canal design and conveyance systems and if possible, these prior sessions should be incorporated into this larger irrigation project.

Session Activities:	
Time	

60 Min.	Trainer reviews data requirements, design criteria and construction techniques for furrow irrigation systems (level, contour, graded, corrugated). Trainees are instructed to collect the necessary data and construct a contour furrow system in a designated field.
90 Min.	Trainees collect necessary data on topography, soils, and crops, and complete system design.
4-6 Hr.	Trainees construct a conveyance system to bring water to the field, lay out and construct the furrows, and construct the tail water drain.
2-3 Hr.	Trainees perform an advance/recession test for a given flow, check water distribution with a soil auger (depth and lateral movement), and check for erosion problems. If necessary, the trainer may need to demonstrate the use of a siphon in order to complete this exercise.

Trainer Notes: This exercise can be done with a local farmer to make the end result very practical.

Materials Required:

* leveling device
* measuring tape
* polyurethane or polyvinyl chloride siphons (1" or 1 1/2")
* sheet of plastic
* shovels, hoes, picks
* soil auger
* stakes
* two poles 1.5 m

References:

Chapter 5, Irrigation Reference Manual: Surface Irrigation Systems

International Irrigation Center Module #23

Session Topic: Sprinkler Systems

Session Goal: Trainees will be able to design, install, operate, and manage a small-scale sprinkler irrigation system.

Session Objectives:

(1) Trainees will collect the field data necessary to design a sprinkler irrigation system.

(2) Trainees will design a small-scale irrigation system that includes at least three to four sprinklers.

(3) Trainees will install a sprinkler irrigation system and prepare a simple operation and maintenance program for the system.

Overview: In this session Trainees develop a small-scale sprinkler irrigation system from the design to operational stage. This completed project can give Trainees confidence in future projects and should provide them with sufficient information to work with sprinklers on a limited scale. This session draws upon the experience obtained in the pipeline design session.

Session Activities:	
Time	

120 Min.	Trainer introduces session by asking Trainees to list reasons why they might choose a sprinkler system in an irrigation design. Trainer indicates if sprinkler usage is or isn't common in-country but points out that either way, understanding the mechanics of these systems is necessary. Trainees brainstorm the data requirements and design criteria for sprinkler systems. Data requirements should include:
	- shape and area of the field,
	- topography (in reference to water source to field),
	- soil characteristics (infiltration rate, water-holding capacity),
	- crop characteristics (water requirements at peak use, rooting depth), and
	- wind conditions.
	Design criteria should consider:
	- water flow rate (required or available),
	- pressure required or available (for pumping station need pump capacity; for gravity flow need elevational difference from water source to field),
	- distance from water source to field (to determine main pipeline length),
	- diameter and length of conveyance pipe and fitting (frictional loss; pipe diameter availability and cost),
	- sprinkler type and nozzle size (flow and wetted diameter at operating pressure; water application rate to match soil intake rate),
	- sprinkler availability: types, sizes, and pressure required, and
	- sprinkler spacing (to achieve adequate uniformity).
	Trainer uses actual sprinklers to demonstrate what all of these concepts mean in terms of metal and moving parts. Trainer then informs Trainees they will now be designing and constructing a very simple irrigation system. Trainees should appoint a facilitator and then work as a group to prepare a material list for this system and establish management criteria. Management criteria should include water application requirements and rates, estimated time to irrigate, schedules, and schematics. Trainer should allow Trainees to complete this activity on their own but should review the final product and offer advice on additional information that should be considered if the Trainees have left gaps in their lists. Trainees are given field data and instructed to prepare a complete design for a system that will include three to four sprinklers. The pipeline length should be kept relatively short, if possible, as this will reduce the amount of field time required. Trainer informs Trainees they will need to make their own materials purchases and that they should appoint a small group to do this task. Allocate one to two hours of training free time for this Trainee group to complete this exercise.
3-5 Hrs.	Trainees travel to proposed work site. As initial task, the group that purchased sprinkler supplies should describe their experience completing this task. Trainer should facilitate a review of the procedures to be followed in constructing a sprinkler system. Trainees then proceed to carry out the installation of their system design.
60 Min.	Trainer reviews Trainees' experience completing the system construction work. Trainer provides brief explanation of system evaluation procedures. Trainer informs Trainees they will need to conduct an evaluation of the system they constructed, and that they should gather materials and plan to complete this exercise.
1-5 Hr.	Trainees work as a group in the field to complete an evaluation of their sprinkler system. This will not be a continuous activity, as there will be considerable lag time while the Trainees wait for water to be applied. This component of the session can be done while Trainees are performing other activities nearby. In conducting the evaluation Trainees should (a) evaluate water application distribution, (b) check pressure at several points along the main line and lateral lines, and (c) check flow rate at sprinkler.

45 Min.	After Trainees have obtained all of their data they can return to the classroom and complete the evaluation using the distribution uniformity coefficients graph. Trainer should lead discussion to determine how Trainees might change any aspect of the process they used.

Trainer Notes: This session involves quite a lot of classroom time, and it may be advisable to break this up over several days in order to maintain Trainee attention spans.

Materials Required:

* bucket
* hoes, machetes, shovels
* leveling device
* plastic cups
* pressure gauge with fittings to insert in line
* screw driver, pliers
* stakes (can be made by Trainees)
* stop watch
* string, measuring tape, plastic or Teflon tape
* sprinkler heads, pipelines, fittings, pressure sources (pump or elevated intake)

References:

Chapter 5, Irrigation Reference Manual: Pipeline Hydraulics and Design; Sprinkler Irrigation Systems International Irrigation Center Module #25

Session Topic: Localized Systems

Session Goal: Trainees will be able to design, install, and operate a low-cost, appropriate technology localized irrigation system.

Session Objectives:

(1) Trainees will describe the basic components that are included in developing a localized irrigation system.

(2) Trainees will design a low-cost localized system.

(3) Trainees will install and operate a localized system.

Overview: This session will introduce localized irrigation to the Trainees. They will be able to design very simple systems, install, and operate them. This session builds on previous sessions that covered pressurized pipeline design and sprinkler irrigation systems.

Session Activities:	
Time	
60 Min.	Trainer asks Trainees to describe criteria that would warrant the use of a localized irrigation system (e.g., limited available water supplies, emphasis on permanent crops in cropping pattern). Trainer brings out materials used in building a localized system and reviews the functions of each component and considerations that should be considered in planning such a system: types of crops being grown, low system pressure, availability of materials, and costs. Trainer demonstrates how components are assembled and diagrams the process of preparing and completing a simple system design for irrigating a tree crop.
30 Min.	Trainees are divided into two groups and assigned the task of preparing a very simple localized system design, using prepared data obtained from one of the work site areas. Design must include a materials list and budget.

60 Min.	Each Trainee group completes purchasing trip to buy locally available materials for use in their localized system construction.
90 Min.	Trainee groups use the materials purchased to construct their system. After completing the system, each group prepares an operation and maintenance plan and demonstrates their system in operation, discussing problems and possible solutions.

Trainer Notes: If the training group is small (ten or less Trainees), then it may not be necessary or advisable to do this session as two groups. The component activities of this session can be split up and done over several days, if this is more conducive to the overall training design.

Materials Required: Leave this up to the Trainees to decide.

References:

Chapter 5, Irrigation Reference Manual: Localized Irrigation Systems
International Irrigation Center Module #26

Exam: Section 6 - Designing system requirements

1. What are five factors that you should consider in the selection and design of an irrigation system?

Answer:

slope	field geometry
soil type and depth	crop
flow rate	erosion

2. You need to construct a channel to convey irrigation water from a stream diversion to a field. You install a 90° V-notch weir in the stream and measure a head of 11 cm. a) What is the flow rate? You decide that a triangular-shaped canal will be the easiest construction for you and the farmer. With your Abney level, you measure a slope of 1.4% for the canal. b) What will the depth of water be for the triangular channel that will convey the measured flow downstream of the weir once uniform flow has been established? Use a rock-lined canal with a side slope of 1:1 (z = 1); c) What is the velocity of the water?

Answer:

a. $Q = 0.014\ H^{5/2} = 0.014\ (11)^{5/2} = 5.6$ liters/sec $= 0.0056\ m^3$/sec

b. n = 0.032
s = 0.014
z = 1

$Q\ AR^{2/3}\ S^{1/2}/n$ (metric)

For a triangular canal,

$A = zd^2$
$R = A/wp = zd^2\ /2d(1 + z^2\ )^{1/2}$

For a triangular canal with z = 1,
d = 0.114 m = 11.4 cm c.

Q = velocity x area, or V = Q/area = 0.43 m/sec

3. A field has a slope of 5%. (a) If the channel is to be built in the same direction as the slope, the channel bottom is to have a 1% slope, and drops are 0.5 meters each, how many drop structures per 100 meters of channel would you need? (b) What type of drop structure would you use?

Answer:

The drops will have to compensate for 4% of slope, or 4 m/100 m. Thus, the number of drops is 4 meters/0.5 m = 8 drops per 100 meters.

4. A farmer knows that the water source is above her field, and she wants to irrigate the land. She goes to the market and buys 4 rolls (100 m/roll) of 1/2" □ (diameter) polyethylene tubing. She installs the main line and, to her surprise, only a trickle of water comes out of the end of the tube. She calls you and asks for advice. What would you tell her, and how would you explain the problem?

Answer:

friction loss in tube
sizing of tube
elevational difference between water source and field

5. In land leveling, what is the main physical factor that determines if the practice can be done effectively? Explain your answer.

Answer:

topsoil depth
plant growth in minimum depth of 30 cm

6. What recommended flow rate would cover a 10 m x 10 m basin with sandy loam soil?

Answer: ≅ 5 L/sec (see Table 5.6, Irrigation Reference Manual)

7. What are the steps in constructing a contour furrow irrigation system?

Answer:

1. survey field
2. lay out guide furrows
3. make furrows between guide furrows

8. For furrows (a) What typical flow rate and length of furrow might you expect on a medium textured soil, down a 2% slope, and with 100 mm of water application? (b) If the furrow were half the typical length, what flow rate might you recommend?

Answer:

a) length = 120 m, Q = 20 L/sec
b) length = 60 m, Q = 10 L/sec

9. Which system generally requires a higher flow rate, borders or furrows?

Answer: borders

10. There is a 30 m elevational drop between the water source and a field that is to be sprinkler irrigated by gravity pressure. A 100 m distance separates them. A farmer wants to irrigate the field, and it will require a flow of 120 L/min. If the minimum operating pressure for the sprinkler system is 30 psi, what size PVC main line would you recommend to the farmer, 1", 1 1/2", or 2"?

Answer:

For the system to work, the elevation head must be greater than the pressure head plus friction losses. For 2" pipe, friction head = 2 m/100 m (Table 5.3, Irrigation Reference Manual), and the operating pressure of 30 psi = 21 m. Thus, elevation head (30 m) > 21 m + 2 m. The 2" size would allow for up to 7 meters of additional friction losses in fittings, etc., and for slightly higher operating pressure.

11. A farmer comes to you and asks how he can eliminate air from the pressurized pipeline in his gravity flow sprinkler system. You accompany him, inspect the main line, and find all the unions to be watertight. Upon arriving at the stream and finding the farmer has placed the inlet of the main line in a fast-flowing, turbulent section of the stream, what is your recommendation?

Answer:

Construct a small diversion.
Put 50 cm head of water over tube inlet in non-turbulent pounded water.

12. Why do you need debris-free water when operating a localized irrigation system?

Answer: to prevent clogging of emitters

13. Name an appropriate technology localized irrigation system.

Answer: perforated polyethylene tubing, with appropriate sized holes, discharging into small basins around trees

Section 7: Farm water management

*** Basic Concepts in Farm Water Management Basic Soil and Water Conservation Practices**
*** Developing Irrigation Schedules**
*** Evaluation, Operation, and Maintenance**
***Exam: Section 7 (Developing Farm Management Plans)**

Session Topic: Basic Concepts in Farm Water Management

Session Goal: Trainees will identify the constraints faced by farmers and the factors that irrigators can apply to achieve optimum results from irrigation.

Session Objectives:

(1) Trainees will identify the benefits that result from good farm water management.

(2) Trainees will list the constraints typically encountered by farmers in improving management practices.

(3) Trainees will identify practices that a farmer can use to improve results from irrigation.

Overview: This session encourages Trainees to begin thinking of irrigation in the context of complete farm systems, from water source to crop yield. Trainees will identify benefits, constraints, and management possibilities important in developing appropriate management practices.

Session Activities:	
Time	
30 Min.	Trainees will list the benefits of proper irrigation system management and identify problems that can arise from poor management practices.

30 Min.	Trainer facilitates a role play in which three to four Trainees represent local farmers, and one to two Trainees represent irrigation Volunteers offering extension advice. The "farmers" should describe some of the constraints they face in just getting out a crop or two. The "extension workers" should try to work within these constraints to come up with an agreeable strategy for incorporating better management practices into the farmers routines, without putting an excess stress into the farmers' lives.
120 Min.	Trainer leads Trainees into the field and informs them that they will conduct a farm reconnaissance to (a) interview the farmer and identify the basic practices being used on the farm, (b) establish the physical makeup of the farmer's irrigation system, and (c) complete an analysis of the farm, complete with recommendations for ways to improve farm water management. Trainer divides the group in half, and each group works with a separate farm to complete the assigned tasks.
45 Min.	Trainees reconvene and present their findings. The groups provide feedback to each other, and the trainer advises Trainees that they will repeat this exercise in the training, although next time they will have to present their findings directly to the farmer.

Trainer Notes: Trainer should locate potential farm evaluation sites that reflect both good and poor management practices. Trainer(s) should meet with farmers before the session and make certain they will be comfortable working with the Trainees in this exercise.

Materials Required:

* any tools the Trainees feel they need
* notebook

References:

Chapter 6, Irrigation Reference Manual: On-Farm Water Management International Irrigation Center Module #40

Session Topic: Basic Soil and Water Conservation Practices

Session Goal: For Trainees to describe the criteria used when applying a variety of techniques that can promote soil and water conservation.

Session Objectives:

(1) For Trainees to determine when erosion controls are needed.

(2) For Trainees to describe criteria for evaluating and selecting the most appropriate erosion control measures for a given site.

(3) For Trainees to design and construct a bench terrace and a gabion.

Overview: Controlling erosion is a major concern for all agriculture Volunteers. Sediment loads can clog ponds, reservoirs, and canals. Soil loss can limit the productivity of agricultural fields. This session provides Trainees with an opportunity to apply some of the basic concepts covered in the session on watershed hydrology.

Session Activities:	
Time	

45 Min.	Session can begin in the field with trainer reviewing some of the concepts covered in the watershed hydrology sessions. Trainer should walk with Trainees through a hilly, but cultivated area of a watershed to point out evidence of different erosion processes and describe the erosion processes occurring. Trainees are asked to list factors influencing soil loss.
60 Min.	Trainees are divided into groups of three. One group constructs a runoff plot with pin and washer and demonstrates its use for estimating soil loss. Other groups should practice building small check dams using brush materials and demonstrate dams' use for slowing runoff and encouraging infiltration and vegetative recovery of the gully.
20 Min.	Trainees remain in groups of three and use their A-frame level to delineate two contours along the hillside spaced approximately 15 meters apart
2-3 Hr.	Trainees reconvene and review the principles for constructing a bench terrace. Trainees now divide into two groups. Each group selects one of the contour lines and constructs approximately 2-3 horizontal meters of a bench terrace with a 2-3 meter base.
25 Min.	Trainee groups present their completed terrace section and describe the experience. Trainees discuss the advantages and disadvantages of terracing and other soil conservation measures and indicate the concerns that farmers are likely to have about incorporating these measures into their daily agricultural practices. Trainees identify strategies they might use to increase farmer incentives to apply soil conservation techniques.

Trainer Notes: Doing this session in the field should make the concepts of erosion and soil conservation much easier for Trainees to grasp. The actual soil conservation techniques covered should be largely dictated by in-country conditions and common practices.

Materials Required:

* A-frame
* axe, machete, shovels, picks, rake, tamper
* hand or Abney level
* large pins or stakes, washers
* stakes, string
* twine or rope

References:

Chapter 2, Irrigation Reference Manual: Soil and Water Conservation Practices

International Irrigation Center Module #19

Crozier, C. 1986. Soil Conservation Techniques for Hillside Farms. Peace Corps Information Collection and Exchange. Reprint Series No. R-62. 96 p.

Gil, N. 1985. Watershed Development with Special Reference to Soil and Water Conservation. FAO Soils Bulletin 44. Food and Agriculture Organization of the United Nations, Rome. 243 p.

Weidelt, H.J. (ed). 1984. Manual of Reforestation and Erosion Control for the Philippines. German Agency for Technical Cooperation. Reprinted by Peace Corps Information Collection and Exchange, Washington, D.C. pp. 393-491.

Session Topic: Developing Irrigation Schedules

Session Goal: Trainees will be able to evaluate the factors that define a farmer's irrigation schedule and will obtain experience in developing simple schedules.

Session Objectives:

(1) Trainees will identify the factors that determine when and how much water to apply before, during, and after the crop season.

(2) Trainees will define the concepts of net irrigation need, allowable moisture depletion, irrigation interval, net depth of application, gross depth of application, and irrigation duration.

(3) Trainees will determine appropriate allowable soil moisture depletion, irrigation intervals, net application depths, gross application depths, and irrigation duration for local crops, soils, and conditions

(4) Trainees will identify the soil moisture levels in a soil and define the time to irrigate using the "feel" method in the field.

Overview: The Trainee must be able to determine appropriate irrigation intervals and amounts, evaluate soil moisture deficits in the field, and determine the time to irrigate in order to improve the efficiency and productivity of irrigated fields. This session builds on information developed during the Assessing Irrigation Water Requirements training sessions and forms a foundation of effective farm management.

Session Activities:	
Time	
75 Min.	Trainees will describe and summarize the factors that affect when and how much water a farmer will apply. They will base this analysis on their recent work in the sessions on Assessing Irrigation Water Requirements and Farm Water Delivery Systems. The trainer should help them refer back to these sessions often if they are not making the link on their own. The trainer will then present the terms: net irrigation need, allowable moisture depletion, irrigation interval, net application depth, gross application depth, and irrigation duration. Trainees will develop definitions for these concepts and attempt to explain them graphically. Trainer will then work through a simple example of how to apply these concepts. Trainer will provide local data, and the Trainees will individually complete the calculations necessary to develop a simple irrigation schedule.
45 Min.	Trainer will take Trainees to the field where they will use the "feel" method to practice evaluating soil moisture and estimating the time to irrigate. By the end of this exercise, the Trainees will be able to estimate soil moisture conditions confidently and apply this information to the preparation of irrigation schedules.

Trainer Notes: For the field exercise, the trainers should select irrigated farms with different soil textures and management practices.

Materials Required:

* local crop and climate information
* soil auger and shovel
* soil moisture "feel" chart
* calculators

References:

Chapter 6, Irrigation Reference Manual: Farm Irrigation Scheduling

International Irrigation Center Modules #2, #3, #8- #11, and #39

Session Topic: Evaluation, Operation, and Maintenance

Session Goal: Trainees will conduct a rapid appraisal of farm irrigation systems, including canals and conveyance structures, and make recommendations for improvement.

Session Objectives:

(1) Trainees will evaluate a farm irrigation system to determine whether the farmer is applying water at the correct intervals and application depths, with adequate uniformity and without excessive runoff or erosion concerns.

(2) Trainees will evaluate the conditions of the farmer's canals, structures, and irrigation systems, and make suggestions for improvements.

Overview: Dramatic improvements in yields and water savings often result from slight improvements in management. Simple evaluations of the physical system and its operation are the key to improving the on-farm performance. This session enables Trainees to consolidate and apply concepts developed in several earlier sessions in the sections on Assessing Irrigation Water Requirements and Farm Water Delivery Systems. Trainees will be able to determine how all of the different practices link together to guide comprehensive on-farm water management.

Session Activities:	
Time	
30 Min.	Trainer will lead Trainees into the field where they will define the methods that can be used for rapid appraisal and evaluation of irrigation systems and the types of changes that farmers can apply.
60 Min.	Trainer has Trainees observe, evaluate, and develop recommendations for improving the operation and maintenance procedures being used by the farmer. This will include measuring flow rates and studying soil conditions.
60 Min.	After the Trainees have confidently determined their recommendations for improvement, they will select one or two representatives from their group to meet with the farmer and communicate their recommendations. These representatives should record the farmer's responses and describe their experience to the full group.

Trainer Notes: While it is certainly preferable for all of the Trainees to gain the experience of communicating their findings to the farmer, it would be overwhelming for a farmer to have to meet with an entire group. The Trainees should carefully select their representative(s), and be certain that consensus has been reached in the operation and maintenance improvements they will be recommending. For their part, the Trainees' representative(s) should be careful to identify the constraints, operating criteria, and options under which the farmer operates.

Materials Required:

* 30 meter tape
* flow measuring device
* stopwatch
* soil auger, shovel

References:

Chapter 6, Irrigation Reference Manual: Evaluation of Existing Irrigation Systems; Training Small-Scale Farmers in Irrigation Management International Irrigation Center Modules #33-#37, and #40

Exam: Section 7 - Farm water management

1. Define: (1) irrigation interval, (2) management allowed deficit, and (3) irrigation duration.

Answer:

Irrigation interval is the spacing between irrigations (days).

Management allowed deficit (MAD) is the allowed soil moisture depletion between irrigations.

Irrigation duration is the time required to irrigate a field.

2. What percent of the available water in the root zone (FC WP) can be extracted from a soil without stressing a lettuce or carrot crop during mid-season? A corn crop? A cotton crop?

Answer:

Lettuce - a sensitive crop - use 30% to 40%
Corn - semi-tolerant - use 50% to 60%
Cotton - tolerant - use 60% to 70%

3. Given a field with a loamy sand soil with AW = 100 mm/m, root depth = 60 cm, and an allowable deficit of 50%, how much water can be depleted below field capacity before irrigation (i.e., what is the management allowed deficit)?

Answer:

MAD = p' x Aw x D = 0.50 x 100 mm/m x 0.60 m = 30 mm

4. What is the required irrigation interval if the soil profile is filled with each irrigation, and daily crop water use ETc is 5 mm/day? (Assume rainfall and groundwater contributions are negligible.)

Answer:

I = MAD /Etc + Ts = 30 mm / 5 mm/day + 1 = 7 days

5. If a farmer irrigates every 7 days while crop water use is 5 mm/day with no precipitation, and overall efficiencies are 50%, what net and gross depth of application will be required?

Answer:

dn = I x ETc = 7 x 5 = 35 mm
dg = dn/Ea = 35/0.5 = 70 mm

6. A farmer waters a 1-hectare field with 10 liters/sec in 24 hours of operation. What is his gross application depth? Answer:

Using the Continuity Equation, QT = dA
d = OT / A

Q = 10 L/sec = .01 m3/sec = 36 m3/hr
T = 2 4 hours
A = 1 ha = 10, 000 m^2
d = 36 m^3/hr x 24 hours / 10, 000 m^2= .086 m = 8.6 cm

7. Describe 5 characteristics of a good irrigation.

Answer:

A good irrigation
1) is uniform
2) is adequate
3) does not have excessive runoff
4) is not erosive
5) is on time
6) minimizes runoff

7) minimizes deep percolation

8. Name 5 factors which the farmer can control to improve his irrigation .

Answer:

1) flow rate
2) irrigation interval
3) duration
4) irrigation method
5) slope

Section 8: Waterlogging and salinity

*** Basic Concepts of Waterlogging and Salinity**
*** Control of Drainage and Salinity Problems**
*** Exam: Section 8 (Assessing Field Problems and Solutions)**

Session Topic: Basic Concepts of Waterlogging and Salinity

Session Goal: Trainees will be able to describe the causes and problems associated with waterlogging and salinity.

Session Objectives:

(1) Trainees will identify waterlogged or salt-affected soils in the field and the probable causes of the problem and will explain difficulties that these conditions will cause for crop production.

(2) Trainees will describe field methods used to identify problems with salinity and alkalinity in soils.

(3) Trainees will learn to use tables to evaluate the effect of soil and water salinity and sodic levels for various crops.

Overview: Waterlogging and salinity can be a serious problem in many irrigated areas. Trainees need to understand how to identify the severity of these problems in the field and work with practices that can improve soil conditions. This session introduces basic concepts and prepares Trainees to work with field practices in waterlogging and salinity control.

Session Activities:	
Time	
45 Min.	Trainer will introduce basic concepts of waterlogging, salinity and alkalinity, and use slides or videos to review typical conditions, tolerant crops, effects on susceptible crops, field identification practices, and analysis procedures that are typically applied. (If video equipment is not available, trainer can use graphics to cover topics.)
60 Min.	Trainer leads Trainees into the field and has them dig shallow holes in waterlogged areas and in well-drained areas. Trainees should compare the soil conditions and the apparent effects on plants in the field. The trainer should discuss with the Trainees probable causes of, and potential solutions to, the problems.
60 Min.	Trainees move to a field site with salinity problems. Observations of effects on plant growth are recorded, and methods for identifying salinity problems in the field are defined. Trainees meet with a local farmer and discuss the farmer's experiences in trying to work with or improve salinity problems.

60 Min.	Trainees visit a sodium affected field and identify areas within the field that demonstrate dispersed soil that has lost its structure. Impacts on crop growth and irrigation water infiltration rates are observed and recorded. Trainees will discuss with the trainer the probable causes of the problem and potential solutions. Again, Trainees meet with a local farmer to discuss the farmer's concerns and experience.
60 Min.	Trainees move to a field where they can conduct some simple experiments. Trainer instructs Trainees to build three small basins. Trainees should prepare three solutions, as follows: (a) plain water, (b) water with a mixture of approximately 0.25 kilogram salt per every four liters of water, (c) water with a mixture of approximately 0.25 kilogram of any chemical fertilizer per every four liters of water. Each basin should be filled with one of these solutions, and allowed to drain. After the solution has completely drained, add a second, and then a third mix to the basin. Trainees should observe and discuss the differences in terms of water penetration and resulting soil structure and color in each basin. Trainees should discuss the long term effects of these conditions on crop growth.
60 Min.	In many countries laboratory facilities are available and tests for salinity and sodium problems can be performed. Trainees need to learn basic skills to enable them to collect samples and interpret lab results. Trainer should obtain soil or water lab results from in-country and use the data to prepare simple problems for the Trainees to analyze. Problems should require the Trainees to consult the following tables: (a) Crop Salt Tolerance Levels for Different Crops as Influenced by Irrigation Water or Soil Salinity, and (b) Effect of Irrigation Water Quality on Soil Salinity, Permeability, and Toxicity (see Chapter 7 of Irrigation Reference Manual). Trainees should classify the soils or water samples in terms of the degree of salinity or sodicity problems evident.

Trainer Notes: This is an important session for Trainees who will be working in arid and semi-arid areas with high water tables and poor drainage conditions. Waterlogging and salinity usually become a problem when water tables are 1 meter or less below the soil surface. Trainers should locate several potential field sites for Trainees to visit and inform farmers of the intent of the visit.

Materials Required:

* 3 buckets
* copies of tables 7.2 and 7.4 from Chapter 7 of Irrigation Reference Manual
* salt, fertilizer
* soil or water lab analysis results
* shovel, hoe

References:

Chapter 7, Irrigation Reference Manual: Waterlogging and Salinity Problems

International Irrigation Center Modules #14 - #17

Session Topic: Control of Drainage and Salinity Problems

Session Goal: Trainees will identify control measures that can be used to eliminate or minimize problems with waterlogging and salinity.

Session Objectives:

(1) Trainees will identify the various soil amendments that can be used to neutralize the effects of sodium salts.

(2) Trainees will determine the timing and amount of leaching required to remove salts from the soil profile.

(3) Trainees will describe the use of artificial drainage to eliminate waterlogging and salinity problems.

(4) Trainees will describe the types of drains required to lower the water table to acceptable levels, including surface drains for evacuation of excess irrigation and rainwater.

(5) Trainees will identify cultural practices that can be used to minimize the effects of salts and waterlogging on yields.

Overview: Drainage design and construction can be a very complex endeavor. Trainees, however, should at least be familiar with the procedures used in this task. The use of soil amendments, leaching, and cultural practices is definitely within the realm of most Volunteers' work responsibilities, and Trainees will be provided with an opportunity to develop these skills in the field. This session expands on basic concepts developed in the earlier session in Waterlogging and Salinity.

Session Activities:	
Time	
45 Min.	Trainer leads Trainees to the field and has Trainees demonstrate their ability to distinguish waterlogging, salinity, and sodicity problems. Trainer introduces simple techniques that can be used to begin to control these problems, including the use of soil amendments, leaching, surface and subsurface draining, and cultural practices.
90 Min.	Trainees are divided into groups of three and assigned the task of estimating and applying the correct amount of soil amendments and quantifying the amount of leaching required to improve conditions in the field they are visiting. Trainee groups describe and document cultural practices that can be employed to improve soil and water conditions. Groups reconvene and compare results and experiences.
60 Min.	Trainer brings Trainees to inspect a farm drainage system. Trainees, continuing to work in their groups of three, graphically delineate the system design, and identify the steps that were apparently followed in developing this drainage system.
45 Min.	Trainees interview a farmer working with the problems of high water table and salinity and conduct a quick visual review of the farmer's situation. Trainees offer general recommendations for the farmer on practices that can reduce or eliminate the problems, being certain to frame recommendations within the limitations of options available to the farmer.

Trainer Notes: Trainers will need to locate areas with waterlogging and salinity problems and identify one or more farmers willing to allow Trainees to visit and study their farms. Trainer should be certain to interview local farmers before this session to learn how they are typically dealing with these problems. The design of subsurface drains is beyond the scope of this training. Surface drains for the removal of excess irrigation and rainwater, however, should be discussed.

Materials Required:

* local information on soils
* soil auger
* transport
* shovel

References:

Chapter 7, Irrigation Reference Manual: Waterlogging and Salinity Problems International Irrigation Center Modules #14, #15, #16, and #17

Ayers, R. S., and Westcot, D.W. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29. Rev. 1. Food and Agriculture Organization of the United Nations, Rome. 161 p.

Exam - Section 8 - Assessing field problems and solutions

1. Describe the soil characteristics of a saline soil that can be seen in the field.

Answer:

White crusts on soil surface.
Plants stunted, appearing to be drought stressed even though soil is moist.
Uneven plant height and soil moisture in the field.

2. Define: (1) EC, (2) amendment, and (3) leaching.

Answer: See Glossary

3. Results of a soil sample analysis come back with an ECe of 2.2 and an ESP of 8. (1) How would this soil be classified? (2) What problems would a farmer expect to encounter when irrigating this soil?

Answers:

(1) Saline-sodic
(2) Drainage and infiltration problems; runoff with heavy irrigations; uneven crops; problems with salt-sensitive crops

4. Using Table 7.2 on crop salt tolerance levels, what yields would you expect for beans? for barley? for carrots?

Answer:

Beans - About 75% of normal harvest
Barley - Normal harvest
Carrots - 75% of normal harvest/d

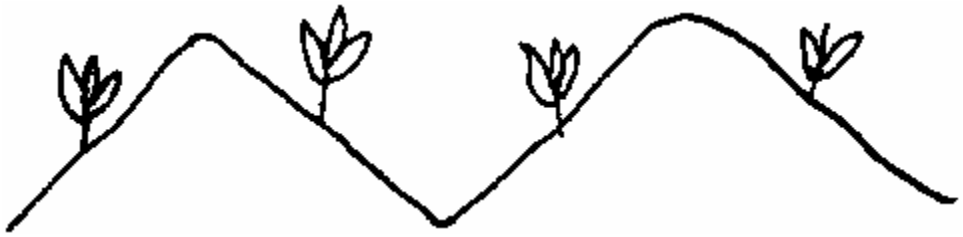
5. How would you identify a waterlogged soil in the field?

Answer:

Gray soils with black or red mottles
Water-saturated soil, standing water in holes 30- 80 cm deep

6. Draw bed shapes and plant locations that would control salinity problems with furrow irrigation.

Answer:



If a farmer wanted to apply 1 ton/ha of pure gypsum to reclaim soils with sodium problems, and only lime sulfur was available, how much lime sulfur would he or she have to apply? How much sulfur would he or she apply in the process?

Answer: Given:

Equivalent
1 Ton of Pure Gypsum
1 Ton of Sulfur

Lime Sulfur 0.78 4.17

a. 78% x 1 ton gypsum = 1 ton lime sulfur
1 ton gypsum = 1.28 tons lime sulfur

b. Applying 1.28 tons lime sulfur x 4.17 = 5.35 tons sulfur

Section 9: Project planning and development

*** Conducting Economic Analyses**
*** Proposal Writing**

Session Topic: Conducting Economic Analyses

Session Goal: Trainees will be able to select the appropriate economic analysis method and apply it to analyze the feasibility of a project.

Session Objectives:

(1) Trainees will be able to describe methods of economic analysis used to evaluate a project.

(2) Trainees will be able to analyze the economics of alternative technologies in a project.

(3) Trainees will be able to demonstrate the use of an amortization table.

Overview: Trainees will need to calculate and analyze the economic feasibility of projects and look at how different options within a project greatly influence its success. They will also need to confidently prepare risk and return factor analyses as part of an overall economic analysis. This session should be presented in tandem with the project planning and proposal writing session.

Session Activities:	
Time	
30 Min.	Trainer asks Trainees to describe the need for economic analysis in a project. What are the common sense economic factors that must be taken into account in conducting a project analysis? Trainer provides a simple example to demonstrate the concepts of: break even point, net present value, partial budgeting, pay back period, and rate of return.
30 Min.	Trainer selects two Volunteers for a role play exercise. One Volunteer will be a small-scale farmer and the other will be an irrigation extension worker. The objective of the extension work will be to convince the farmer that it is worth the risk of investing some present time to construct an irrigation system. Unfortunately, it is now very close to planting time, and the farmer is concerned about the danger of getting crops in late or not at all. Dialogue should bring out the concerns and innate wisdom of both individuals.
30 Min.	Trainer then facilitates a discussion of the following: what is more important to a farmer -> the economic risk taken in a project or the economic return expected from a project? How might a farmer prioritize these concerns and on what basis?
60 Min.	Trainees are divided into two groups, A and B. The groups are instructed to conduct an analysis of a development project. Group A uses the following methods (Risk Analysis): (1) rate of return, (2) break-even point, and (3) pay back period. Group B uses the following methods (Return Analysis): (4) rate of return and (5) partial budgeting. Groups are given basic project data and determine the economic feasibility using each method. Each group presents findings to entire group. Merits of each method are discussed by the Trainees as a full group.

60 Min.	Trainees remain in the same groups. Trainer provides data on the following:
	- prices of pipe: PVC and polyethylene
	- expected life of piping material
	- interest rate
	- project life
	Group A analyses the economic feasibility of using polyethylene while Group B analyses the economic feasibility of using PVC. Each group presents their findings, and discusses the factors that would influence their final decision. Trainer concludes session by asking Trainees to describe how they would communicate these concepts to small-scale farmers in a rural setting.

Trainer Notes:

Materials Required:

* data on expected life of tube materials
* handouts with examples of computed economic feasibility analyses.
* pricing information for local materials

References:

Appendix B. Irrigation Reference Manual: Economic Analysis

Appendix D, Irrigation Reference Manual: Case Studies

Session Topic: Proposal Writing

Session Goal: For Trainees to identify and apply practices necessary to prepare project proposals and plan simple irrigation projects.

Session Objectives:

(1) For Trainees to identify factors that influence the initiation, design, management, maintenance, and documentation of projects.

(2) For Trainees to identify and describe practices and procedures that can assist in time management on a project.

Overview: In the course of their service Volunteers will very likely take on the task of planning a small project and writing a proposal to leverage funds for the project. In this session trainers guide Trainees to identify the key factors involved in preparing a project plan and writing a project proposal. Trainees also are provided with an opportunity to test their skills in planning a hypothetical project.

Session Activities:	
Time	
30 Min.	Trainer asks Trainees to define "project." Example: Any specific activity carried out for a definite purpose or goal, within a defined time frame, and with defined resources. Trainer asks Trainees to define "program." Example: An integrated group of continuing activities directed at implementing many projects. Have Trainees describe the kinds of projects and programs they see themselves being involved in. Trainer discusses three basic components of effective project planning and management: 1) clear, precise, plans for a finite project (has a beginning and an end), 2) based on appropriate information and resource assessment, and 3) involves the appropriate people from within and outside the community. Trainer then divides Trainees into three groups and assigns each group a topic from these three components. Trainee groups are given 10 minutes to list the factors and strategies that are necessary to accomplish successfully these three components. Example:

	A. Plans
	- clear, concise, realistic goals and objectives,
	- alternative strategies to achieve goals and objectives,
	- comprehensive task list,
	- schedule/timeline for tasks,
	- organizational development and administrative procedures in place,
	- community involvement in designing plans,
	- on-going evaluation mechanisms, and
	- maintenance measures.
	B. Resource and Information Gathering
	- appropriate data about cultural and physical conditions, and
	- accurate interpretation of community needs and ambitions.
	C. Involvement of Appropriate People
	- identify community leaders,
	- work with a motivated community, and
	- working with motivated agencies.
30 Min.	Trainer presents brief lecture on project planning and proposal writing, using case examples where possible, and plenty of visual aids to demonstrate how these concepts are applied to small-scale irrigation projects. Discussion should include advantages and disadvantages of proactive versus practive planning. For example:
	A. Reactive Planning
	- passive acceptance of events,
	- response to immediate problems,
	- short-time crisis management, and
	- lack of overall coherent plan.
	<u>Advantages</u>
	- limited responsibilities required, and
	- very little time or financial investment. required
	<u>Disadvantages</u>
	- are always working at a crisis pace,
	- are not looking ahead to future needs,
	- often lose sight of original goals, and
	- find successful conclusions are rare; more often move from one crisis to next.
	B. Proactive Planning
	- active on-going management of project tasks,
	- advance planning and setting of goals,
	- contingency planning to overcome obstacles, and
	- evaluation and continual improvement of project.
	<u>Advantages</u>
	- anticipate and respond to actual needs,
	- organize of resources available,
	- garner enthusiasm and participation of community,
	- maintain track to goal completion, and
	- frequently have successful conclusions.
	<u>Disadvantages</u>
	- requires time, skills, and considerable effort,
	- requires organization, participation, and lots of people, and
	- requires a considerable amount of management responsibility and decision making.
	Trainer moves on to outline a step-by-step approach to project planning. This can appear something like the following:

Technical	**Social**	**Financial**

1. Feasibility study(preliminary)	1. Project initiation by community	1. Water Association formed
2. Social/technical survey	2. Design consultation with community	2. Membership/ responsibilities assigned
3. System design	3. Organizing tasks, training	3. research funding options, organizations
4. Proposal preparation	4. Community mobilization	4. Proposal presented to funding source
5. Construction	5. Evaluations	5. Funds and materials
6. Operation and maintenance	6. Organizational functions, meetings	6. Disbursement of funds, finance management
7. Project documentation	7. Next community: priorities/projects	

30 Min.	Trainer has Trainees describe the components of a complete project proposal. Trainees should describe the content and format of a proposal and the level of detail that is necessary to make a proposal understandable and appealing to a reader. Trainer walks Trainees through a sample proposal that was successfully financed to do an in-country project. Trainees critique the proposal, then modify their own description of an effective proposal. Trainer briefly reviews a list of potential funding sources that can be leveraged by Volunteers. This list should be country-specific and appropriate to host country conditions.
45 Min.	Trainer gives Trainees the following assignment to be done independently by each person: Identify or imagine one project that you can see yourself working with at your site within your first year. Prepare an outline of the procedures and tasks that you anticipate doing as a part of this entire project process. Then put together a rough outline for a project proposal that you will help draft to solicit funds for this project.
15 Min.	Have Trainees reunite and share what they came up with. Identify problems or uncertainties, and indicate areas in which more skill development will be necessary.

Trainer Notes: The discussion of proposal writing can be best facilitated by having a current or recent Volunteer who successfully financed a project with a written proposal come in and share her or his experiences. Have this Volunteer describe the entire process she or he went through from developing the initial project idea to writing the proposal to managing the money once it arrived. Be certain to work with a Volunteer that did not do everything alone in a vacuum but acted as a participant in a community proposal development process.

Materials Required:

* list of potential donors with addresses and contacts
* sample project proposals from in-country projects

Selected References:

Appendix B. Irrigation Reference Manual: Proposal Writing