WATER AND SANITATION
FOR HEALTH PROJECT

Operated by
CDM and Associates

Sponsored by the U.S. Agency
for International Development

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The WASH Project is managed by Camp Dresser & McKee International Inc. Principal cooperating institutions and subcontractors are: Associates in Rural Development Inc.; International Science and Technology Institute, Inc.; Research Triangle Institute; Training Resources Group; University of North Carolina At Chapel Hill

TRAINING IN OPERATIONS AND MAINTENANCE OF PUMPS FOR RURAL WATER SYSTEMS IN BOLIVIA

JULY 14 - AUGUST 1, 1986

WASH FIELD REPORT NO. 195

SEPTEMBER 1986

Prepared for
the USAID Mission to Bolivia
WASH Activity No. 228

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by

Amy A. Titus

September 1986

Water and Sanitation for Health Project
Contract No. 5942-C-00-4085-00, Project No. 936-5942
is sponsored by the Office of Health, Bureau for Science and Technology
U.S. Agency for International Development
Washington, DC 20523

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EXECUTIVE SUMMARY

A USAID-sponsored course was held in Cochabamba, Bolivia, from July 14 to August 1, 1986, to train rural water systems supervisors to operate and maintain a variety of pumps, including centrifugal, gasoline, and handpumps.

This course was the second in a series of three courses designed to strengthen the operations and maintenance activities of the Rural Sanitation Department (Departamento de Saneamiento Ambiental -- DSA). The first course was on general operations and maintenance practices and was held May 26 through June 13, 1986. The third will be a training-of-trainers workshop in November, 1986 so the DSA technicians can in turn train community operators. The training team for the pump maintenance course consisted of a trainer from the United States, an engineer from Costa Rica, two engineers from the DSA, one engineer from the Institute for Hydraulics and Hydrology, and one technical trainer from the Institute for Trade Skills Development (Servicio Nacional de Formacion de Mano de Obra -- FOMO). There were 22 participants: 17 from DSA, the remainder from CARE, SEMAPA (the water authority of Cochabamba), and FOMO. The course was held at FOMO, a technical training school with large well-equipped workshops and facilities. The training consisted of short classroom presentations examining theory and experience; practice in the workshop and at FOMO installations; and field trips to rural communities for practice training in the installation, operation and maintenance of pumps and related equipment.

According to both participant and trainer assessments, the course was very successful. Not only had the course achieved its goals and objectives, but the participants felt more confident and more motivated to carry out the various skills they had mastered. The success was due in large part to the preplanning initiated months in advance and to the logistical support of the WASH Project, the USAID Mission, DSA, and FOMO in setting up the training facilities and field sites. FOMO greatly facilitated the workshop. Practice sessions were conducted at the FOMO workshop and lunch was provided on campus. Thus, participants were able to concentrate on the tasks at hand and had immediate access to the facilities, tools, and equipment necessary for their learning.

The following recommendations are a result of the course:

- USAID should continue its activities to support the critical development of operations and maintenance efforts in DSA. The most immediate action is to support the third course in the series -- the training-of-trainers -- and the subsequent training of community operators by the supervisors.

- DSA should provide the supervisors with the necessary equipment and tools, information, and support they need to carry out their new operations and maintenance responsibilities. This includes

  - the basic tools and equipment required to conduct an inspection of a system and complete minor repairs,

  - a file that contains information describing each community system (kind of pump, history, type of well, etc.),

- assistance from and communication with the DSA engineers when problems arise as well as during site inspections by the engineers,
- a workshop at DSA Cochabamba that will check new equipment, equipment repaired locally, and all equipment before it is taken to the field,
- the utilization of FOMO as a site for major repairs of pumps and related equipment,
- the provision of materials such as promotional materials and easy-to-use operation and maintenance manuals,
- transport, and
- current tariff information.

- USAID and DSA should increase and improve their supervision of the design and construction of new systems.
- DSA should actively contact rural communities with new systems and provide them with operations and maintenance support in order to maintain a demand for DSA services.

Chapter 1

BACKGROUND AND INTRODUCTION

In Bolivia approximately 10 percent of rural areas have access to a potable water system.[1] When these systems were built the tasks involved in operating and maintaining them were not clarified as a responsibility for either the community or the Rural Sanitation Department (DSA). Since 1980, attention has focused on the number of these newly constructed systems that have become inactive due to the lack of maintenance. A large amount of capital has been invested in constructing water supply systems, and DSA has increasingly realized the importance of maintaining them properly. Therefore, training DSA supervisors and community operators in operations and maintenance activities has become a more pressing need.

USAID/Bolivia asked the WASH Project, authorized by AID's Science & Technology Bureau, to assist DSA in providing training in operations and maintenance to 25 supervisors and 150 community operators in the Cochabamba-Chuquisaca USAID project area. Following a series of discussions with the mission, which included a planning visit by Oscar Larrea in September 1985 under WASH Activity No. 178 and the discussions with Ellis Turner, WASH Associate Director, during his visit to Bolivia in January 1986, four activities were envisioned.

The first was the general operations and maintenance workshop held from May 26 to June 13, 1986. The second activity, which is the subject of this report, was a workshop in pump maintenance for the same participants. This workshop focused on the maintenance of a variety of pumps. The third activity will be to develop a course for training community operators in basic operations and maintenance of a water supply system and to conduct a training-of-trainers workshop in November 1986 for 12 to 15 of the DSA technicians so that they can deliver the course. The final WASH activity is to supervise the pilot testing of the community operator course for 25 participants. After the pilot, the DSA technicians will train 125 community operators and continue to implement the operations and maintenance system established in DSA in conjunction with these activities.

The pump maintenance workshop took place July 14 through August 1, 1986. The participants were supervisors from DSA, CARE, SEMAPA (the water authority for the city of Cochabamba) and FOMO (the Institute for Trade Skills Development). As a result of its participation, FOMO will be able to repeat the same course in the future. A list of the participants and their organizations is found in Appendix A.

The aim of this three-week workshop was to orient supervisors to the operation and maintenance of pumps and provide them with the skills required to maintain a variety of pumps and related equipment, detect and correct problems, complete minor repairs in an appropriate manner, and work with the community to establish a simple preventive maintenance program. Chapter 3 provides an overview of the workshop sessions; and Appendix B lists the materials and equipment required to conduct the course.

[1] International Drinking Water Supply and Sanitation Decade Directory, Second Edition, March 1984, World Health Organization.

Chapter 2

PLANNING

2.1 Planning in the United States

The WASH consultants for this assignment were Amy Titus, a training specialist, and Jorge Murillo, a specialist in operations and maintenance. The initial planning for the workshop on pump maintenance began in April, 1985. The assignment involved two visits to Bolivia. The first trip was to carry out a needs assessment and plan the workshop. The second trip was to conduct the workshop. After WASH consultants Dan Edwards and Oscar Larrea had completed the needs assessment for tne general operations and maintenance workshop in February, 1985 (the first workshop), Edwards briefed Titus on the results. The planning of the second workshop was greatly facilitated by their initial groundwork.

Titus and Murillo went through a team planning meeting at WASH on April 10 and 11, 1986 for the needs assessment visit. During this meeting, the consultants were briefed on the background of the assignment, discussed their scope of work, drafted an outline for their interim report, and developed a work plan for the needs assessment visit. Both consultants then departed for Bolivia on April 12, 1986.

2.2 Workshop Design

On April 14, 1986, Titus and Murillo were briefed by Gerry Bowers (USAID health officer), Rafael Indaburu (USAID project manager) and Raul Bascon (USAID advisor). The consultants, accompanied by Bascon, then left for Cochabamba on April 15 to conduct a needs analysis. Meetings were held with the local engineers and 15 supervisors to discuss problems, perceptions of the situation, and training needs. Four field sites were visited; three had problems with their pumps.

During the trip to Cochabamba, FOMO was inspected as the possible site for the workshop. FOMO is a technical training institute with excellent facilities including large classrooms, spacious workshops, and an audiovisual room. The institute also offered the possibility of carrying out practice sessions on its existing water system (one well and two pumps).

Titus and Murillo analyzed their findings based on the interviews and field trip and identified the following major problems:

1) Many systems suffer from faulty design. Incorrect equipment is often selected at the start and then coupled with poor site construction and equipment installation.

2) The construction of water systems is inadequately supervised and problems are not detected or corrected.

3) The electrical system lacks protective equipment. For example, communities lack voltage controls in case of voltage irregularities.

4) Although the majority of supervisors have far more than five years of experience in the field, they lack basic technical knowledge about operations and maintenance of pumps.

5) Community operators lack the skills and knowledge necessary to manage and maintain a pump-driven water system.

6) Supervisors lack the equipment and tools necessary for simple repairs. In addition, DSA has no workshop where repairs may be conducted or where repaired equipment may be tested before it is returned to the community.

7) Literature concerning the installed equipment is not available. As a result, the supervisor and the community must work with incomplete information.

8) No operations and maintenance program exists for pumps and related equipment. Thus the community is at the mercy of local electricians and other repair persons who overcharge for their services.

After identifying which of the problems could be resolved by the workshop, the consultants prepared a list of the skills and knowledge supervisors should have to operate and maintain pumps adequately.

The consultants returned to La Paz on April 16 after two days in the field. A meeting was held with DSA, CARE, USAID, and the instructors to discuss findings, analyze the list of identified training needs, and achieve a consensus regarding the focus and goals of the workshop.

The following week was spent designing the workshop sessions and planning its logistics. All instructors participated in designing the goals, objectives, format, equipment requirements, and content and activities of the workshop. A model based on the principles of adult learning was followed in designing the sessions. The instructors prepared the sessions in which they had the most expertise. Where there was overlap in expertise, the instructors worked collaboratively. Overall it was a successful team effort. The week ended with the development of a work plan. Each instructor was to prepare his sessions by a certain date. DSA was put in charge of obtaining for the workshop the equipment and tools which neither FOMO nor DSA had in stock.

2.3 Training Staff

The training staff consisted of Amy Titus, who served as team leader and coordinator of instructional methodology, and the following subject matter experts:

1. Engineer Jorge Murillo, a consultant from Costa Rica, an expert in pumps.

2. Engineer Jorge Henrich Medina, DSA's national director for operations and maintenance.

3. Engineer Javier Pino, DSA Cochabamba, director of operations and maintenance.

4. Engineer Eduardo Fernandez, an expert in hydraulics and hand-pumps from the Institute for Hydraulics and Hydrology.

Fernando Alvarez, the executive director of FOMO and technician Fernando Montano, technical director of FOMO, served as assistants during the workshop.

2.4 Final Preparation

WASH consultants, Titus and Murillo, returned to Bolivia on July 7 for final preparations during this week. The entire training staff reviewed what remained to be done and got everything ready for the workshop to begin on July 14.

Chapter 3

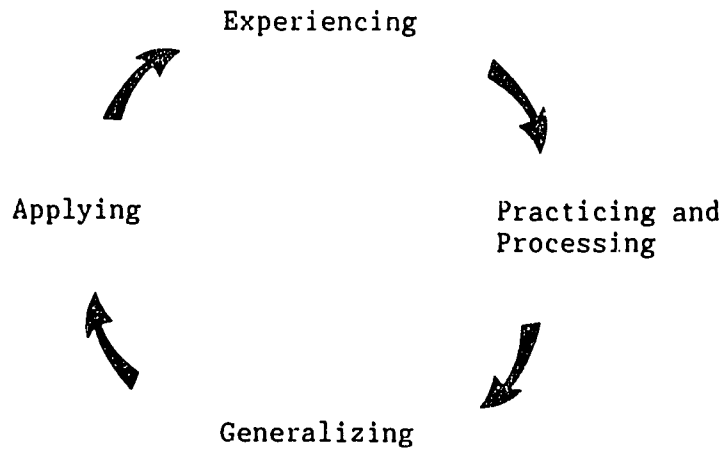
IMPLEMENTATION

3.1 Location

The workshop was held at FOMO in Cochabamba, Bolivia from July 14 to August 1, 1986. Cochabamba was selected for the training because it is centrally located in the USAID-DSA project area. Communities with problem pumps ideal for practice sessions are close to Cochabamba. FOMO was chosen because the installation offered spacious classrooms, a workshop with adequate space and the necessary equipment and tools. In addition, a local restaurant was contracted to provide lunch on site. Thus the participants were able to stay at the training site all day without interruptions or distractions.

3.2 Methods

The training methods used were based on principles of adult learning theory and included experiential training techniques. The methods are participant centered, and they create an active approach to learning and assume that the responsibility for learning is shared between trainers and participants. A four-step process was followed in each training session:



The sessions were taught by two instructors: one who had designed the session and an assistant. The sessions were held in the classroom, the workshop, on the grounds of FOMO, and in local communities. They generally started with a brief overview of theory or principles and a sharing of experiences and knowledge. This was followed by a practice session and then an analysis of the practice. Discussions were then held concerning how these skills would be applied in the field. Actual application of the learning was completed at FOMO, during field trips, and by solving everyday problems the supervisors faced in their jobs.

3.3 Workshop Goals

Upon completion of the workshop, the participants were to be able to

1. Be aware of the importance of preventive maintenance of pumps and related equipment in rural water systems.

2. Describe relevant theory and principles of pumps and related equipment.

3. Identify and use electromechanical equipment and tools.

4. Describe the different types of spring cappings and wells and how they are maintained.

5. Diagnose problems in pumps and related equipment.

6. Make the appropriate decisions regarding repairs, based on the results of the diagnosis.

7. Complete basic repairs of pumps and related equipment.

8. Develop a program in the operations and preventive maintenance of pumps and related equipment.

9. Transmit basic knowledge to the community about a system for preventive maintenance of pumps, related equipment, and the surrounding environment (well, protection, etc.).

3.4 Workshop Schedule

The workshop consisted of 105 hours of classroom instruction and practice over three weeks. The first week was spent accomplishing the first three goals listed above. The second week covered goals four through seven, and the last week focused on the last two goals.

A complete workshop schedule is provided in Figure 1. This schedule gives an overall picture of the time spent on each session as well as the general flow of activities. Minor modifications were made in the schedule based on unforeseen complications concerning the installation, operations, and maintenance of equipment during practice sessions.

3.5 Participants

Twenty-two participants (17 from DSA, 2 from CARE, 2 from FOMO, and 1 from SEMAPA) completed the course. The seventeen DSA supervisors came from Cochabamba, La Paz, Chuquisaca, Oruro, and Potosi. The two participants from CARE came from Potosi and Oruro. The participant from SEMAPA (the water authority for the city of Cochabamba) worked in operations and maintenance. The two FOMO participants, both FOMO instructors, were specialists in electricity and motors.

Figure 1

Course Schedule: The Operations and Maintenance of Pumps and Related Equipment

July 14, 1986 to August 1, 1986

	7/14/86	7/15/86	7/16/86	7/17/86	7/18/86	7/19/86
8:30	Introduction Ice-breaker Expectations Course Goals	I.3 Valves I.4 Principles of How a Pump Works	I.6 Types of Motors	I.8 Review of Module I II.1 Use of Tools	II.3 How to Install Pumps	No class
12:30	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	----
1:30 5:00	I.1 Hydraulics & Mechanical Principles I.2 Types of Pumps	I.5 Electricity	I.7 Electric Controls & Gears	II.2 Use and Maintenance of Valves and Accessories	II.3 Continued	
	7/21/86	7/22/86	7/23/86	7/24/86	7/25/86	7/26/86
8:30	II.3 Continued	I.5 Maintenance of Hand Pumps I.6 Review of Module II	III.1 Types of Spring Cap-pings & Wells III.2 Sanitary Conditions	IV.1 Common Problems IV.2 Methods of Solution	IV.3 Maintenance of Pumps and Related Equipment	Field Trip: Pandoja Round Table for Engineers
12:30	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	----
1:30 5:00	II.4 Field Operation of Pumps and Motors	I.7 Visit to SEMAPA	Mid-Course Evaluation	IV.2 Continued	IV.4 Minor Repairs	
	7/28/86	7/29/86	7/30/86	7/31/86	8/1/86	----
8:30	V.1 Operations & Preventive Maintenance Program for the Supervisor	V.3 Practice in the Field	V.3 Continued	V.3 Continued Course Review	Closing Ceremony	
12:30	LUNCH	LUNCH	LUNCH	LUNCH	BANQUET	-----
1:30	V.2 O&M Program for the Community	V.3 Continued IV.4 Minor Repairs	V.3 Continued	Course Evaluation		

3.6 Training Sessions

3.6.1 Introduction (Monday, July 14)

The workshop began with an introductory welcome by Engineer Jorge Henrich. The participants then introduced themselves by stating where they were from and what they did. The staff trainers then introduced themselves and explained their role and expertise. An ice breaker was conducted to build a comfortable climate. The expectations of the participants were elicited through a group exercise and then were discussed, compared, and clarified in light of the workshop goals and schedule. A definition and discussion of the training methodology used in the workshop was provided. Norms for the group were discussed.

3.6.2 Module I: Function of Pumps and Related Equipment

This module contained eight sessions.

Session 1. Hydraulic and Mechanical Principles of Pumps (Monday, July 14)

Objective: To enable the participants to understand the basic principles of hydraulics and the mechanics of a pump in order to explain how a pump works. An overview of the principles was provided. The participants had to define the basic principles and solve simple problems given data about a typical Bolivian village.

Session 2. Types of Pumps and their Components (Monday, July 14)

Objective: To enable the participants to identify different kinds of pumps and their parts. A brief overview of different kinds of pumps and their parts was provided using graphics and posters. The participants then went to the workshop where they observed pumps and their parts and then identified different parts of pumps in small groups.

Session 3. Valves and Accessories (Tuesday, July 15)

Objective: To enable the participants to classify the different kinds of valves and accessories, their functions, and their components. A brief overview of different kinds of valves and accessories and their functions was provided utilizing cut-outs of valves to show their parts. The participants then practiced analyzing various valves, identifying their components and defining their purposes.

Session 4. Principles of How a Pump Works (Tuesday, July 15)

Objective: To enable the participants to describe the operation of a pump and explain the process of its operation under different conditions. The theory behind the operation of a pump was provided. The curves that describe its operation were shown and explained using examples. The pump at FOMO was analyzed, removed, checked, reinstalled and then put into operation. Various problems occurred which were discussed enthusiastically in great detail. Given data, the participants then analyzed several pumps in the workshop and described their operations.

Session 5. Basic Principles of Electricity (Tuesday, July 15)

Objective: To enable the participants to 1) explain the fundamental principles of electrical conduction, 2) describe how these principles apply to pumps and electric motors, and 3) interpret information about electrical systems in motors and pumps. The basic principles of electricity were presented and illustrated with everyday examples. The participants then completed two examples in the classroom that required them to apply the principles learned.

Session 6. Electric and Gasoline Motors and their Parts (Wednesday, July 16)

Objective: To enable the participants to identify the different types of electric and gasoline motors and their parts. The various kinds of motors, their parts and operations were explained. The participants reviewed a variety of electric motors in FOMO's workshop and identified their parts and functions in small groups. A brief overview of gasoline motors was given by one of the instructors. This was later supplemented during the analysis of the session. The participants were very excited and involved in this activity.

Session 7. Electric Controls and Switch Gears (Wednesday, July 16)

Objective: To enable the participants first to identify the types and parts of electric controls and conductors and then to assemble and connect a system and put it into operation. After a brief introduction to the topic, the participants broke into small groups and went to the FOMO workshop where they were asked to select the appropriate equipment, hook it up to a pump motor, and put the motor into operation. The groups then examined each other's work to see different motors in operation. Finally the groups reported what they had learned. This session was hampered by the lack of switch gears in working order at FOMO. Groups had to test a number of gears before finding any that functioned.

Session 8. Review of Module I (Thursday, July 17)

The participants reviewed the workshop content covered thus far. Two topics were assigned to each group to be summarized for the class. The class then asked the groups questions about the sessions they had summarized. This method worked well except that the groups had some trouble summarizing critical topics. Instead they reported back information provided on the handouts. However, the class was lively and asked many questions.

3.6.3 Module II: Electromechanical Equipment and Tools

This module contained seven sessions.

Session 1. Use and Maintenance of Tools and Equipment (Thursday, July 17)

Objective: To enable the participants to demonstrate the correct use and maintenance of tools. A long but necessary explanation regarding the use and maintenance of tools and equipment was provided in the workshop. Practice consisted of using the more difficult and foreign equipment to measure pumps, electricity, and other equipment in the FOMO workshop.

Session 2. Use and Maintenance of Valves and Accessories (Thursday, July 17)

Objective: To enable the participants to explain the use and maintenance of valves and accessories. After a brief introduction, the class was divided into four small groups. Each group was assigned the task of providing maintenance to valves. Three groups went to the FOMO workshop and cleaned and maintained valves. A fourth group inspected and maintained the four valves in FOMO's pumps. This last task was complicated and, as a result, the other three groups joined them when they were done with their own projects. Two of the FOMO pump valves were in poor condition and the pumps had to be removed. The participants energetically cleaned and repaired the valves as well as the corresponding pipes. This task took longer than expected due to the fact that the system at FOMO had not been maintained since it was installed fifteen years ago.

Session 3. How to Install Pumps (Friday, July 18 and Monday, July 21)

Objective: To provide the participants with guided practice in installing a pump in the field. The community of Pandoja was chosen because its horizontal pump had been judged to be inadequate for the work demanded of it. Thus the participants' job was to remove the existing horizontal pump and install a more powerful vertical pump. The participants were divided into four small groups and given specific tasks. Two groups went directly to the site and removed the existing pump. The other two groups went to DSA to collect materials. This activity was delayed because the equipment request had not been filled and, in addition, stock had been incorrectly inventoried. Various stores in Cochabamba were searched and eventually the essential materials were purchased.

When the latter two groups arrived on site, all groups energetically proceeded to work on their tasks. Finally when the vertical pump was fully installed late in the day, the participants found, much to their chagrin, that it did not work. After explaining the problem to the community, the instructors and participants agreed to return Monday to resolve the problem. The conclusion was that the pump had been forcefully inserted during the initial bypass and that this action had resulted in cutting or damaging the cable.

On Monday the groups returned to the site and removed the pump. They found that the cables had been scraped on the side of the well and their insulation damaged. The participants agreed that they should have checked the motor and cables prior to installation and then at each pass of the installation on Friday. All the participants tested the motor and resolved the problem with the cable. They were very proud that they were able to verify a problem and then correct it. The pump was reinstalled after the bottom union connecting the pump and the well was changed. This was done to insure that the cable went down smoothly and did not wrap around the pump. However, the pump still did not work. The participants removed the pump again and checked it, but it simply did not work. Tired and depressed, the participants removed the pump, closed the pipes, and returned to the classroom to analyze the situation. They all agreed on the following general points:

- A pump must be checked mechanically and electrically before it is installed.

- Better planning for such an exercise should be done so that all necessary equipment is available.

- The literature that goes with a pump should be read and consulted before the pump is installed.

- Specific tasks must be assigned to group members or effective work does not always get done.

The participants thought the existing pump was adequate and disagreed with the DSA engineers who wanted to exchange it for an expensive--albeit a more powerful--pump. In addition, the information provided by DSA about the system was empirical and inadequate--the well's history and its exact size were not known.

Overall the participants agreed that the session had been a tremendous learning experience. However, they all felt badly that the community did not have an operative pump. The instructors and the participants agreed to return Saturday to reinstall the pump after an analysis of the pump was conducted and the problem corrected (an electrical problem).

Session 4. Field Operation of Pumps and Motors (Monday, July 21)

Objective: To enable the participants to explain the basic principles of how pumps operate and the steps of their operation, to identify the function of each part, and finally to interpret the various aspects of a pump's operation (voltage, number of phases, velocity, etc.). The session was conducted in the field at Pandoja. A question and answer period followed using the pump and motor at Pandoja as examples.

Session 5. Maintenance of Handpumps (Tuesday, July 22)

Objective: To enable the participants to learn the characteristics of a basic handpump maintenance program and to decide what actions to take to solve a particular problem. After an introduction to the components of a handpump maintenance program, the participants completed a practice session. They were given a series of problems and their causes and had to describe the appropriate actions to be taken.

Session 6. Review of Module II (Tuesday, July 22)

In small groups the participants prepared four questions that they wanted to present to the class regarding the content of Module II. Each group presented its questions in turn and the class responded. The instructors intervened to clarify and correct answers.

Session 7. Visit to SEMAPA (Tuesday, July 22)

An afternoon visit to the water treatment plant of SEMAPA (the water authority for the city of Cochabamba) was organized. At FOMO, the class was divided into four groups. Each group was given a specific task to investigate at SEMAPA. Upon arrival at the plant, all participants were first given a tour through the plant. They then broke into groups and conducted their analysis. Upon return to FOMO the findings of the groups were presented. A general discussion followed concerning the lack of operations and maintenance activities and the inadequacies of public service bureaucracies.

3.6.4 Module III: Types of Spring Cappings and Wells

This module contained two sessions.

Session 1. Types of Spring Cappings and Wells (Wednesday, July 23)

Objective: To enable the participants to identify different types of wells and spring cappings and their parts. Using the knowledge of the participants, the principal characteristics of spring cappings and wells were recorded. In groups, the participants analyzed and described the different types of wells and cappings they encountered in their work. A general discussion of the presentations of each group ensued.

Session 2. Sanitary Conditions for the Function of Wells (Wednesday, July 23)

Objective: To enable the participants to learn the standards for locating wells and spring cappings and to analyze the captations and wells in their regions and describe their sanitary protections and conditions. The instructor, jointly with the participants, identified the sanitary conditions for and places where spring cappings and wells should be located. However, in the exercise, the participants did not understand that they were to analyze the wells in their regions and see if they met the standards. Instead they presented the standards that they would like to see implemented in their areas! When asked why the conditions in their areas did not meet the standards, the participants discussed the complexities of working with communities and maintaining the standards.

Invited Speaker: Cleaning of Wells

The chief of operations and maintenance at SEMAPA spoke regarding the different ways to clean wells and then conducted a question and answer period.

3.6.5 Mid-Course Evaluation (Wednesday, July 23)

For a mid-course evaluation the participants were asked to spend five minutes thinking through and writing down their responses to this question: what have you learned so far. After five minutes of reflecting and recording, pairs were formed to share and compare what they had learned. Each pair was also asked to list the areas in which they felt they needed strengthening. The group discussed what they had learned. The majority responded that their lists were very similar. Each pair presented a point in which they felt they particularly needed more work. The points were duplicated by most pairs and were as follows:

- order and attention to detail in their tasks,
- interpretation of pump curves,
- use of electric apparatus,
- understanding of gasoline motors, and
- assembly of motors and pumps.

The session closed with a question and answer game called "Bet Your Pump." Two

teams were formed. A question was presented to both teams and the team that responded first and correctly gained points. If an incorrect answer was given, the team lost points and the other team was given the opportunity to provide the answer. The game was thoroughly enjoyed by both the participants and the instructors.

3.6.6 Module IV: Diagnosis of Problems, Repairs, and Adoption of Actions

This module contained four sessions.

Session 1. Common Problems Encountered with Pumps, Motors, and Related Equipment: Methods of Diagnosis, Causes and Consequences (Thursday, July 24)

Objective: To enable the participants to determine the causes and consequences of maintenance problems. First the instructor used a graphic to describe a methodology for detecting problems. The participants then answered a series of questions that described situations in which they determined the problems, their causes, and consequences.

Session 2. Methods of Solution and Actions To Be Taken (Thursday, July 24)

Objective: To enable the participants to make the appropriate decision about how a specific maintenance or repair should be completed. The session started with a review of the various levels of decision in DSA and how and to whom the supervisiors should pass their decisions concerning repairs. The participants went to the FOMO workshop in groups, analyzed a series of pumps, and determined the correct action to take. This activity included dismantling the pumps and noting the problems encountered, the actions taken, and the actions to be taken. The participants then returned to the classroom and presented their work and findings group by group.

Session 3. Maintenance of Pumps and Related Equipment (Friday, July 25)

Objective: To enable the participants to describe the components of each piece of equipment that needs maintenance, interpret maintenance program cards, and design a program of preventive maintenance. After a brief guided discussion of preventive maintenance and preventive maintenance programs, the participants broke into small groups and proceeded to design their own programs. Each group was assigned a type of pump and given a maintenance table to fill in for the pump given. Each group then presented its program. The participants expressed great satisfaction in completing this activity.

Session 4. Minor Repairs (Friday, July 25)

Objective: To enable the participants to complete minor repairs on pumps, motors, and related equipment. A brief introduction was given in the classroom. The participants then proceeded to work in groups in the FOMO workshop completing minor repairs on vertical and horizontal pumps.

The pump that was to have been installed in Pandoja was analyzed and a simple electrical problem was found to be the culprit. The repair was made and the pump was tested in the well at FOMO. The results were successful.

At the end of the day the participants discussed their learning experiences. They said that there was not enough time to finish their work and test their

pumps in the FOMO well. The instructors explained the constraints of a course but said that Tuesday afternoon, July 29, the participants could finish their work and test their pumps.

3.6.7 Field Trip: Pandoja (Saturday, July 26)

Approximately half of the participants, those who did not have obligations, arrived at FOMO at 8 a.m. to install the pump at Pandoja. The pump was installed very capably by the participants while the instructors observed. The participants tested the pump at each pass. Finally when the pump was started, the water was turbid. It turned out that the well had been dormant for four years. The instructors and participants agreed that the well should have been cleaned first and, most important, that the pump should have been turned on slowly so as not to stir up the silt and sand at the bottom of the pump.

The participants were extremely pleased with having successfully installed the pump.

3.6.8 Round Table for Engineers (Saturday, July 26)

The round table was geared to DSA engineers. Its purpose was to provide a forum for the engineers to discuss their problems and talk with Engineer Murillo about how to design pump installations and select the right pump. A brief presentation of problems was given by the participating engineers from Cochabamba and La Paz. Engineer Murillo then gave an overview of design and selection criteria. The engineers visited three communities that presented problems: Pandoja, Hauiraya Ujaica, and Pajamarca Callpu. In each case an inappropriate pump had been selected. The problems, their causes, and solutions were discussed at each site. The round table participants then met for an hour to analyze what they had seen, to establish short-term plans of action to ameliorate the problems in each community, and to establish a series of recommendations. The round table participants felt that there was a need for

- a course for engineers on design and pump selection;
- easy-to-use manuals on operations and maintenance in Spanish for the engineer, supervisor, and community;
- improved communications between the engineers;
- more field visits on the part of engineers, particularly the AID project advisors; and
- more supervision of sites in construction and operation.

3.6.9 Module V: System of Operations and Preventive Maintenance

This module contained three sessions.

Session 1. Operations and Preventive Maintenance Program of Pumps for the Supervisor (Monday, July 29)

Objective: To enable the participants to identify the activities that should

be part of a preventive maintenance program and then develop a preventive maintenance program for pumps and related equipment in their areas. This session built upon what had been covered in Section 3.6.6, Module IV, Session 3, requiring that the participants apply what they had learned. The participants broke into groups according to their regions and prepared programs for the kinds of pumps in their regions. Each group then presented its work and a lively discussion followed.

Session 2. Operations and Preventive Maintenance Program of Pumps for the Community (Monday, July 29)

Objective: To enable the participants to know what actions are necessary to organize a community and form a preventive maintenance program at the local level and what tasks the local operator should carry out routinely to implement the program of preventive maintenance. The participants briefly discussed how to initiate a program in preventive maintenance in the community and then broke into groups. Each group listed the activities that are necessary to initiate and support such a program. After analyzing the programs presented, the participants agreed that the process is not easy. The participants then conducted two dramatizations in which they practiced explaining to an imaginary community what a program of preventive maintenance would consist of. The discussion following the dramatizations centered mainly around the importance of a tariff increase to pay for a local village operator and to purchase the necessary replacement parts and the possible negative reaction to these comments by the community. The supervisors stressed the need for simple, convincing language and the use of examples to educate the community about the concept of preventive maintenance.

Session 3. Practice in the Field (Tuesday, July 29, Wednesday, July 30, and Thursday, July 31)

Objective: To enable the participants to apply in the field what they had learned during the workshop. The participants broke into two groups: Group A and Group B. On Tuesday each group planned its work and presented its plans. Each group member was assigned a task and a large graphic depicting a preventive maintenance schedule was developed by each group.

On Wednesday, Group A analyzed the pump and related equipment in the community of Paucarpata and explained a program of preventive maintenance to the local water board. Group B observed and evaluated the work of Group A using a set of observable criteria. In the afternoon Group B conducted similar activities in Pinami while Group A observed.

The practice sessions went very smoothly on Wednesday. Both communities were friendly and receptive.

On Thursday each group made a presentation describing what it had done and what it had learned. The other group gave its evaluation. In both presentations, group members had interrupted the person giving the talk to the community and made improper remarks. The importance of following plans and self-discipline were discussed. The participants also realized that they must plan their presentations in more detail. Both groups had neglected to develop an action plan for the community. Another observation concerned the value of simple graphics and clear explanations when presenting the preventive maintenance program. The session ended with a discussion of how the participants were going to promote preventive maintenance programs in their areas.

3.6.10 Closure

1. Course Review (Thursday, July 31)

Four problems were distributed, one to each group. Each problem was a real problem that instructors had detected in the field. The participants did an outstanding job of describing the problem, its cause, its consequences and its solution. Both the instructors and participants noted proudly that the participants were able to think and solve problems in the classroom and work effectively in the FOMO workshop as well. The session closed with a review of the course content.

2. Course Evaluation (Thursday, July 31)

A short discussion was conducted concerning how the participants felt about the course, its strong and weak points. Very positive opinions were expressed. A course evaluation form was distributed and completed by the participants. The findings of this form are reported in Chapter 4.

3. Closing Ceremony (Friday, August, 1)

A formal closure for the workshop was held. Engineer Henrich initiated the session. Titus spoke about the workshop goals, activities and accomplishments. The certificates were distributed. The participants then made a presentation regarding the course. The closure ended with words from Dr. Suarez from the Ministry of Health and Engineer Navarro, the Director of DSA. A lunch then followed for all the participants, instructors, and invitees.

Chapter 4

ASSESSMENT OF THE WORKSHOP

4.1 Participant Evaluations

The participants were very pleased with the design and implementation of the workshop. This was demonstrated by their lively participation in the sessions, their willingness to stay late and complete the analysis of their work in the FOMO workshop, and by their comments on the final evaluation forms. The participants did not attend all sessions due to personal problems. The two participants from CARE arrived late, one on Tuesday, July 15, and the other on Wednesday, July 16.

The evaluation conducted after the two field trips to Pandoja generated criticisms from the participants regarding the lack of planning of the field trip and the lack of adequate tools for installing the pump. However, after discussion the participants agreed that the experience had been overwhelmingly positive--they were able to learn far more from their mistakes and from the problems encountered than if the pump installation session had proceeded smoothly without incident.

The mid-point evaluation identified the need to reinforce electrical and pump operation skills. The participants needed more concrete practice in these two areas of course content. However, overall the mid-point evaluation served to illustrate how much the participants felt they had already learned.

The final evaluations were very positive. The evaluation form and a composite of the goal attainment scores and comments are included in Appendix C. The overall goal attainment for the workshop was 4.4 (on a 5 point scale) with a high of 4.9 for Session I.3 on "Valves and Accessories" and a low of 3.8 for Session II.3, "How to Install Pumps" (the field trips to Pandoja). See Table 1 for the evaluation results.

The most positive aspects of the course for the participants were the practice sessions in the FOMO workshop and in the field. The participants were very satisfied with the training methodology used. The sessions and information they felt were most useful included the principles of hydraulics and electricity, minor repairs, how pumps operate, types of pumps, how to diagnose problems, and the maintenance of pumps and related equipment. All the instructors were highly rated except for the instructor who gave the talk on gasoline motors.

The sessions that were rated the lowest included those on types of spring cappings, on wells, and on gasoline motors. The instructor designated to cover gasoline motors gave a short presentation that was quite inadequate, as the participants noted.

Table 1

Evaluation Results

Objective	Score
I. Function of Pumps and Additional Equipment	
1. Identify basic concepts	4.5
2. Familiarize with different types of pumps	4.65
3. Identify general concepts of valves	4.9
4. Identify principles of how a pump operates	4.2
5. Select the correct electric motor	4.25
6. Familiarize with different types of motors	3.9
7. Familiarize with electrical controls	4.3
II. Electrical Equipment and Tools	
1. Familiarize with the use and maintenance of tools and equipment	4.7
2. Learn a general program for using and maintaining valves and accessories	4.65
3. Familiarize with the assembly and installation of pumps and related equipment	3.8
4. Familiarize with the operation of a pump	4.1
5. Identify how to maintain electrical equipment and apply this to maintenance forms	4.3
6. Identify components of a handpump maintenance program	4.45
III. Types of Spring Cappings and Wells	
1. Familiarize with the types of wells and spring cappings in the project area	4.5
2. Identify the actions to take in order to improve sanitary conditions	4.5
IV. Diagnosis of Problems, Repairs and Actions	
1. Detect and diagnose problems	4.55
2. Utilize criteria to determine solutions	4.15
3. Familiarize with minor repairs of pumps, motors, and related equipment	4.45
V. System of Operations and Preventive Maintenance	
1. Apply programs of operations and preventive maintenance to the work of the supervisors	4.6
2. Identify actions to organize and train the community in preventive maintenance	4.6
3. Apply learning to the field	4.35

The participants identified the following areas for improvement:

- allow more time for practice sessions,
- begin and end the sessions on time,
- give more time for field trips,
- improve the planning of the field trips,
- emphasize electricity more,
- show a film on operation and maintenance of pumps.

The handouts were highly rated; however, the participants felt that they should have been distributed directly after the session to which they pertained instead of the next day. Other comments included the need to make sure that the next course is implemented promptly with improved logistical support, namely sufficient equipment, available transportation, and a copier on site.

The participants noted that to use their training in the field they would require the following:

- the correct tools,
- information about the systems, pumps, and their electrical components,
- an operation and maintenance manual about pumps,
- information about the pumps from the manufacturers,
- the funds needed to do the job,
- promotion activities and materials to educate communities about preventive maintenance.

4.2 Trainer Assessments

The assessments of the trainers reflected the same very positive evaluation of the participants and the same concerns for improvement. The trainers felt that the goals of the workshop were attained and that almost all the objectives of the individual sessions had been met. They also felt that the goals of the course were appropriate to the needs and skill levels of the participants. In particular the trainers noted the increased confidence of the participants and their ability to use technical language correctly and organize their work more effectively.

The points made by the participants during the mid-course evaluation were very much in accord with the evaluation of the instructors. The instructors also agreed with the need for more preparation before a field visit--particularly the importance of checking all equipment before use.

At the final course evaluation, the trainers felt that the lack of logistical support was the major problem during the course. The following specific difficulties were identified and recommendations proposed:

- Photocopies: The photocopy machine was located at the Cochabamba DSA office instead of at FOMO (as it had been in the prior course). (The machine was located at DSA for security reasons.) The materials for copying sent to the DSA office were never completed on time so the participants always received their handouts late.

  Recommendation: In future courses locate the copying machine at the course site but remove a fuse or take some other action so that the machine is not abused after hours by non-course personnel.

- Transportation: The necessary additional vehicles requested for field trips were not always available. The truck assigned to the course kept breaking down.

  Recommendation: In future courses, request additional transportation well in advance and conduct a complete maintenance of the course truck before the course to ensure that it is in working order.

- Educational equipment: An opaque projector had been promised for the course but never materialized. Thus the materials to be used with the projector were not utilized.

  Recommendation: In future courses, the design of courses should only include the educational equipment that is readily available and in working order.

- Equipment and tools: During the workshop the participants and instructors were hampered by the lack of necessary equipment. The problem was due to FOMO and DSA not delivering promised equipment. Also switch gears and other electrical equipment at FOMO were in poor working order.

  Recommendation: In future courses, the necessary equipment should be procured before the course and the equipment at FOMO and DSA should be tested to ensure that it is in working order.

- FOMO: The instructors reported that FOMO did not prepare its sessions and did not complete its tasks.

  Recommendation: In future courses all instructors used in the course should be qualified and have done their work before the course.

The instructors felt that the course did not need to emphasize the following points as heavily:

- the theoretical operation of pumps,
- how to calculate the performance curve of a pump, and
- dismantling and assembling a pump.

The course should aim to be as appropriate as possible to the work demands of the supervisors. The instructors also discussed how to fine tune the sequence

of the course by eliminating the duplicate sessions on how pumps operate and the diagnosis of problems.

Because of the problem with an unprepared and unqualified instructor, the instructors recommended that such a course should be taught by engineers. Technicians should collaborate but not instruct.

The instructors felt very strongly that all instructors should be trained in the methodology of adult learning. Speakers or instructors who do not know the methodology being used should not be asked to participate. The correct implementation of the methodology was felt to be critical to the course's success.

Overwhelmingly the trainers were very positive about the workshop, its goals and content. The instructors rated the workshop as very successful.

Chapter 5

RECOMMENDATIONS

This consultant's recommendations fall into three categories: first, the improvement of this course; second, the need for future training; and third, ways for USAID and DSA to ensure that the training has an impact and that problems with pumps are alleviated.

5.1 Improvement of the Pump Maintenance Course

Content: Future courses should spend more time on all aspects of electricity, including related equipment such as multitesters, testers, switch gears, and control equipment. Additional practice time in the workshop is required. Gasoline motors should also be covered in greater depth.

Materials and Equipment: Future courses should include enough equipment and tools for two groups to simultaneously install pumps in different communities. In addition, the basic tools required for the course must be available and in working order. All materials and equipment must be checked before the course starts to ensure that they are in working order. See Appendix B for a list of equipment required to conduct the course.

Planning: More preliminary local planning is required to conduct such a technical course. Equipment and materials must be acquired two weeks before the course. The installations where the course is to be held should be checked and the necessary equipment and materials located and put into working order. Preliminary planning should also be done for the two practice pump installations and the field visit. The participants require advance information about the following:

- the installation: its size, conditions, and history,
- the depth and shape of the well,
- the tank,
- the community, and
- the pump being installed or used.

Logistics: Smooth procedures for photocopying materials should be established so that participants receive the necessary materials directly after the session is delivered.

Sequence: The sequence of the sessions should be reexamined. Session II.4, "Field Operation of Pumps and Motors", should be combined with Session I.4, "Principles of How a Pump Works", and Sessions IV.1 and IV.2 should be combined into one session on the diagnosis of problems.

Instructors: An instructor should be included who is experienced in the area of electricity. All instructors should preferably be engineers and be qualified in their areas. In addition, all instructors should be trained in and use the methodology of adult learning.

5.2 Need for Future Training

Village Operators: The village operators in the project area require training regarding the operations and maintenance of their systems and pumps in order to effectively work with the supervisors to implement a community preventive maintenance program.

Training in Electricity: One or two supervisors in the Cochabamba project area should be trained specifically in the area of electricity.

Repeat the Workshop: This workshop should be repeated for supervisors in other areas of Bolivia who work with pumps. Many of the problems encountered can be handled effectively by the supervisors or efficiently referred to the correct level for action to be taken. The workshop appears to be a cost-effective approach whereby supervisors can conduct maintenance activities with communities rather than leaving communities to the mercy of local repair shops that overcharge or letting them go without a potable water system. If the other supervisors who work for DSA are similar to the participants, the course would benefit them.

Course on the Design of Pump Installations: DSA engineers require a short one-week course, in the design of pump installations and the selection of equipment. Currently, the pump installations and equipment are incorrectly and inconsistently designed and selected.

DSA Instructors: The instructors in DSA should be trained in greater depth regarding further aspects of human resources development, i.e. performance analysis, recognition and description of training needs, design of solutions, and evaluation. This would create an in-house capability for an ongoing human resources development program.

Follow-up: Refresher training for the supervisors regarding the operations and maintenance of pumps should be conducted in one year. Two days of discussion concerning problems and the introduction of new practices would be sufficient.

5.3 Recommendations for USAID and DSA

5.3.1 USAID/Bolivia

Complete Series of O&M Courses: Most urgently, the series of operations and maintenance courses should be continued and supported. The training-of-trainers course should be delivered in October to maintain the schedule, and the community operators courses should follow shortly thereafter. The momentum is critical because the supervisors are very motivated and view their continued training as vital.

Follow-up: USAID should follow-up with DSA to ensure that the tools and transport the supervisors require to carry out their new tasks are provided in a timely fashion. In addition, USAID should continue its support of DSA's operation and maintenance activities to ensure that a strong program emerges that enables the supervisors to use their new skills.

Supervision: More supervision is required of the water supply systems currently being designed and constructed in the project area. USAID advisors, located at DSA, should conduct this supervision and should require that DSA build a stronger supervision component so that equipment and funds are not

misused. For example, in two communities design and construction problems were noted. In Ayoma contaminated water can seep into the system currently being built, and in Alto Alianza, construction is inadequate.

Contractor Criteria: To keep costs down, in some cases contractors have subcontracted to unskilled laborers who have done inadequate work. If this is a trend, USAID should discuss with DSA the feasibility of modifying the criteria by which contractors are selected.

Evaluation: In one year, an evaluation regarding the impact of training the supervisors should be conducted. The following should be investigated:

- change in performance of the supervisors,
- change in performance of the community,
- operation and maintenance programs in communities, and
- support of operation and maintenance activities in DSA.

5.3.2 DSA

Support of the Supervisors and the O&M Program

DSA should immediately purchase and provide each supervisor with the basic tools required to conduct preventive maintenance and minor repairs. The equipment should include:

1 multitester
1 set of screwdrivers
1 set of star wrenches
1 set of plain wrenches
1 set of corona wrenches
1 set of stilson wrenches
1 pipe threader 1/2" - 2 1/2"
1 hacksaw
1 file 18"
1 set of pliers

DSA should make transport available to the supervisors so that they can complete their community visits. This includes repairing the motorcycles and keeping them in working condition.

DSA should develop a central file that contains technical information about its various systems and pumps as well as any other relevant information. This material should be made available to its supervisors.

The engineers should assist the supervisors when necessary and provide them with the technical information they need to do their work. The engineers should also consult the supervisors when making design decisions or when supervising construction sites or problem sites.

The workshop being constructed at DSA Cochabamba should be completed as soon as possible. This workshop should check new pumps, pumps repaired locally, and all other equipment before it is taken to the field.

The tariff issue should be examined in light of the requirements brought about by maintenance activities and the need to pay a community operator.

Supervisors should be fully informed concerning tariff requirements in the communities.

FOMO should be utilized for the repair of pumps and related electrical equipment.

Equipment and materials

DSA should buy a pump operated by a gasoline engine to be used only for testing well capacity.

DSA should demand that they receive and should subsequently store for general use all the technical information on all their equipment (e.g., installation, operations and maintenance catalogs). This information should be kept in the storeroom and used on a borrow basis.

Follow-up

DSA should consider developing promotional materials to assist supervisors in introducing the concept of preventive maintenance to the community. Possibilities include posters, slides, and other simple graphics.

Easy-to-use operations and maintenance manuals should be developed for each type of pump in use in the project area. These manuals could then be used by the supervisor and the community operator.

Supervision

Engineers should supervise works under construction more closely in order to prevent the anomalies that have resulted in inoperative pump systems.

DSA should prevent contractors from subcontracting to untrained personnel for installation or to build the tank. This situation becomes worse when contractors fail to supervise the work of their subcontractors.

Institution strengthening

DSA should improve its management. In particular it should establish continuity from design to operation of a system. The system should not be designed, nor should the pump be selected until the engineers visit the field and discuss the matter with the community and the supervisor. This will help ensure that both the technical and social criteria of a successful installation are met.

DSA should consider developing an ongoing in-house capability for human resources development. This could be implemented by training current course instructors as described above. These personnel could identify training needs and organize and deliver refresher training as required.

Within the next six months, DSA should strengthen its operations and maintenance activities. It needs to contact all the rural communities that have new systems and provide them with operations and maintenance services. This kind of future vision is needed to provide a demand for DSA services and to help DSA maintain its growth and stability in operations and maintenance.

APPENDIX A

PARTICIPANTS

COURSE ON THE OPERATION AND MAINTENANCE OF PUMPS

DSA (Cochabamba)

Freddy Gamboa
Jose Olguin
Jose Diaz
Jesus Siles
Efrain Molina
Avelino Salinas
Simon Nogales
Guido Ramallo
Lucio Jimenez
Victor Hugo Ustaris

DSA (Chuquisaca)

Nestor Perez
Raul Moore
Jaime Reyes
Edgar Flores

DSA (La Paz)

Roberto Lucio Luna

DSA (Oruro)

Juvenal Maidana

DSA (Potosi)

Humberto Zambrana

SEMAPA

Willy Halkier

CARE

Jaime Vasquez (Potosi)
Hugo Juanez (Oruro)

FOMO

Paz Alarcon
Oscar Aguilar

APPENDIX B

EQUIPMENT NECESSARY FOR THE COURSE

1) Estuche completo de herramientas
   - llaves fijas 1/8" - 2" . Sistema inglés
   - " " de corona 1/8" - 2" " "
   - set de cubos de 1/8" - 2"
   - set de desarmadores 6" - 18"
   - llaves fijas, de corona, set de cubos igual dimensión que las anteriores pero milimétricas.
   - alicates
   - martillos
   - llaves de tubo 6", 6", 8", 12"
   - llaves francesas 4 - 12"
   - " inglesas 4 - 12"
   - " de cadena para 1" Ø - 2"Ø, 3"Ø, 4"Ø y 6"Ø
2) 4 rollos de cinta aislante
3) 1 multiprobador (voltaje, amperaje, ohmios)
   (de 0-600 voltios min.y resistencia 0-500,000 Ω ohmios)
   1 multiprobador de gancho para medir amperaje. (de 0-100 amperios mínimo)
4) 2 engrasadores (1 pequeña, 1 mediana)
5) 2 tarrajas (completa con dados para 1/2"Ø - 4"Ø
6) Extractores de 3", 4", 5" y 6"
7) Válvulas de compuerta, globo, mariposa, alivio, etc. de 3/4"Ø-3"Ø, (nuevas, usadas o dañadas), 1 de cada tipo y Ø
8) 2 controles para desconectar motores por bajo o alto nivel de agua.
9) Sierras manuales
10) 1 docena de hojas de sierra
11) 2 escuadras pequeñas metálicas
12) Martillo
13) Alicate tipo eléctrico para cortar cable eléctrico
14) Alicate de puntas para extraer seguros
15) 6 equipos de control de motores eléctricos que contengan lo siguiente: arrancadores y contactos magnético de C.A., relés o elementos térmicos para sobrecarga, interruptor termomagnético.

Cantidad	Capacidad-Arrancador	Interruptor Termomagnetico
1	1 HP, 10, 230 voltios, 50 HZ	20 amperios
1	1 HP, 10, 115 " "	40 amperios
1	2 HP, " , 230 " "	30 amperios
1	2 HP, " , 115 " "	50 amperios
1	3 HP, 30, 230 " "	20 amperios
1	5 HP, 10, 230 " "	60 amperios

16) Modelos de bombas
   -- horizontal (2)
   -- vertical (2)
   -- sumergible
   -- mano: agua
   -- mano: aceite
   -- motobomba

17) Tripode y tecle

18) Motores electricos
   -- horizontal
   -- sumergible
   -- vertical
   -- combustion de 2 tiempos y de 4 tiempos

19) Repuestos para valvulas danadas

20) Llaves Stilson - 36" de largo

21) Llaves Allen a) sistema metrico
   b) sistema ingles

22) Lampara estrodoscopica y tacometro

23) Medidor de compresion

24) Medidor de vacio (vacumetro)

25) Prensa portatil p/tuberia 1 1/2"o a 4"o

26) Desatornilladores o desarmadores tipo phillips (juego)

27) Control de nivel de agua (electrodo y capsulas de mercurio)

28) Abrazaderas p/columna de 2"o, 2 1/2"o, 3"o

29) Teflon (8 rollos)

30) Cinta vulcanizante (2 rollos)

Cantidad	Capacidad-Arrancador	Interruptor Termomagnetico
1	1 HP, 10, 230 voltios, 50 HZ	20 amperios
1	1 HP, 10, 115 " "	40 amperios
1	2 HP, " , 230 " "	30 amperios
1	2 HP, " , 115 " "	50 amperios
1	3 HP, 30, 230 " "	20 amperios
1	5 HP, 10, 230 " "	60 amperios

16) Modelos de bombas
   -- horizontal (2)
   -- vertical (2)
   -- sumergible
   -- mano: agua
   -- mano: aceite
   -- motobomba

17) Tripode y tecle

18) Motores electricos
   -- horizontal
   -- sumergible
   -- vertical
   -- combustion de 2 tiempos y de 4 tiempos

19) Repuestos para valvulas danadas

20) Llaves Stilson - 36" de largo

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27) Control de nivel de agua (electrodo y capsulas de mercurio)

28) Abrazaderas p/columna de 2"o, 2 1/2"o, 3"o

29) Teflon (8 rollos)

30) Cinta vulcanizante (2 rollos)

APPENDIX C

FINAL EVALUATION

EVALUACION

CURSO DE OPERACION Y MANTENIMIENTO DE BOMBAS

Parte A: Evaluación del Curso

Indique el grado de alcance de las metas, detallado abajo.
Ponga un circulo en el número indicado: 1 = Meta no alcanzada, 3 = Regular, 5 = Muy bien.

I. FUNCIONAMIENTO DE BOMBAS Y EQUIPOS ADICIONALES

1. Principios Hidraúlicos y Mecánicos de una Bomba: 4.5

Establecer los conceptos básicos hidraúlicos y mecánicos y su relación con el funcionamiento de una bomba.

No alcanzado — Regular — Muy bien
1 2 3 4 5

2. Los Tipos de Bombas: 4.65

Familiarizar a los participantes en los diferentes tipos de bombas.

No alcanzado — Regular — Muy bien
1 2 3 4 5

3. Válvulas y Accesorios en Tuberías: 4.9

Conocer el concepto general de válvulas y accesorios, sus características, funciones y clasificaciones.

No alzanzado — Regular — Muy bien
1 2 3 4 5

4. Operación de Bombas: 4.2

Aprender los principics, bajo los cuales opera una bomba.

No alcanzado Regular Muy bien

1 2 3 4 5

5. Conocimientos Esenciales de Electricidad: 4.25

Aprender a seleccionar o utilizar adecuadamente un motor eléctrico, cuando se use con bombas.

No alcanzado Regular Muy bien

1 2 3 4 5

6. Tipos de Motores Eléctricos y Combustión Interna y sus Componentes: 3.9

Familiarizar a los participantes en los diferentes tipos de motores eléctricos y a combustión interna.

No alcanzado Regular Muy bien

1 2 3 4 5

7. Controles y Conductores Eléctricos: 4.3

Familiarizar a los participantes en los diferentes tipos de controles y conductores.

No alcanzado Regular Muy bien

1 2 3 4 5

II. EQUIPOS ELECTROMECANICOS Y HERRAMIENTAS

1. Uso y Mantenimiento de Herramientas y Equipo Comprobador: 4.7

Familiarizar a los participantes en el uso y mantenimiento adecuado de herramientas y equipo.

No alcanzado Regular Muy bien

1 2 3 4 5

2. Uso y Mantenimiento de Válvulas y Accesorios: 4.65

Aprender un programa general para el uso y mantenimiento de válvulas y accesorios.

No alcanzado Regular Muy bien

1 2 3 4 5

3. Montaje e Instalaciones de Bombas y Equipos Electromecánicos: 3.8

Familiarizar a los participantes en el montaje e instalaciones de bombas y equipos.

No alcanzado		Regular		Muy bien
1	2	3	4	5

4. Operación de Bombas (eléctricas y a combustión): 4.1

Familiarizar a los participantes con la operación de una bomba con motor eléctrico, horizontal y - vertical, y con un motor de combustión interna.

No alcanzado		Regular		Muy bien
1	2	3	4	5

5. Mantenimiento de Bombas, Motores, Electricos y de Combustión: 4.3

Adiestrar a los participantes en el mantenimiento de equipos electromecánicos. Aprender a aplicar los conceptos de métodos en las cartas de mantenimiento.

No alcanzado		Regular		Muy bien
1	2	3	4	5

6. Mantenimiento de Bombas de Mano: 4.45

Dar a conocer un programa general para el mantenimiento de bombas de mano.

No alcanzado		Regular		Muy bien
1	2	3	4	5

III. TIPOS DE CAPTACIONES Y POZOS

1. Descripción de Tipos de Captaciones y Pozos: 4.5

Familiarizar a los participantes con los diferentes tipos de pozos y captaciones existentes en el área del proyecto.

No alcanzado | Regular | Muy bien

1 2 3 4 5

2. Condiciones Sanitarias de Pozos y Captaciones: 4.5

Capacitar a los participantes en la serie de acciones que se deben cumplir para lograr condiciones sanitarias en los diferentes tipos de pozos y captaciones.

No alcanzado | Regular | Muy bien

1 2 3 4 5

IV. DIAGNOSTICO DE FALLAS, REPARACION Y ADOPCION DE ACCIONES:

1. Principales Fallas: Sus Causas y Consecuencias: 4.55

Adiestrar a los participantes en la detección y diagnóstico de fallas en los diferentes equipos electromecánicos y la adopción de acciones a seguir para la reparación respectiva.

No alcanzado | Regular | Muy bien

1 2 3 4 5

2. Métodos de Solución y Toma de Decisiones: 4.15

Enseñar a los participantes a utilizar criterios para adoptar métodos de solución y para decidir las acciones a seguir.

No alcanzado | Regular | Muy bien

1 2 3 4 5

3. Reparaciones Menores: 4.45

Familiarizar a los participantes en reparaciones menores en bombas, motores y equipos.

No alcanzado | Regular | Muy bien

1 2 3 4 5

V. SISTEMA DE OPERACION Y MANTENIMIENTO PREVENTIVO

1. Sistema de Operación y Mantenimiento para el Técnico: 4.6

Capacitar a los técnicos en la aplicación de programas de operación y mantenimiento preventivo de bombas, instalaciones y equipos en general.

No alcanzado		Regular		Muy bien
1	2	3	4	5

2. Programa de Operación y Mantenimiento para la Comunidad: 4.6

Familiarizar a los participantes en las acciones que deben realizar para organizar y adiestrar a la comunidad en programas de mantenimiento preventivo de modo que la comunidad sea capaz de seguir las rutinas de un programa.

No alcanzado		Regular		Muy bien
1	2	3	4	5

3. Práctica en el Campo: 4.35

Aplicar lo aprendido en su área de trabajo.

No alcanzado		Regular		Muy bien
1	2	3	4	5

Parte B: Evaluación de la Metodología del Curso

Favor de escribir sus observaciones sobre la efectividad de la metodología del curso para los siguientes puntos.

1. ¿Cuán práctico y aplicable fue el adiestramiento? Comentarios y observaciones:

An excellent and easy method, theory and practice with the motors, group work and field work, practical 70%, applicable 80%.

2. ¿Cuales fueron los métodos más efectivos del curso (ejemplos: trabajos en el taller, visitas al campo, estudios de caso, dramatizaciones, exposición de tema, charlas interactivas, disertaciones, etc.)? Comentarios y observaciones:

All, detect problems, workshop and field visits, group work, discussions.

3. ¿Entre todas las sesiones cuales fueron sobresalientes en el adiestramiento y cuales fueron menos efectivas? Observaciones:

All, excellent: hydraulics, electricity, minor repairs, development of preventive maintenance program, work in the workshop, how pumps operate, types of pumps, diagnosis of problems

worst: wells, gasoline motors

4. **Favor de indicar lo más importante que se ha aprendido en este curso.**
Explicaciones:

Knowledge for routine work, how to dismantle and assemble a pump, share experiences, minor repairs, calculate the potency of a pump, develop a preventive maintenance program, detect problems, electricity, organization and cleanliness

5. **¿Qué deberíamos hacer para mejorar el curso la próxima vez que se lo dicte? (contenido, secuencia, nivel, tiempo, ubicación, instrucción, etc.)**
Observaciones:

More time for practice, improve timing and sequence, more field trips, plan field trips better, a film about operation and maintenance of pumps, more on electricity

6. **Favor de Presentar sus observaciones sobre los entrenadores:**

A. Ing. Henrich:

B. Ing. Fernández:

C. Ing. Pino:

D. Ing. Murillo:

E. Lic. Titus:

F. Lic. Alvarez:

G. Tec. Montaño:

7. **¿Cuán útiles fueron los materiales didácticos utilizados (boletines, folletos, etc.)?**

Positive-very useful, need to handout right after session

8. **Para llevar el trabajo de la operación y el mantenimiento de bombas bien en el futuro, ¿cuales informaciones, herramientas y destrezas le faltaría a usted ahora?**

Read and study, more funds, the necessary equipment, promotion activities, information about the systems and pumps, information about the electrical systems, manual on the operation and maintenance of pumps, manufacturer literature, another course more in-depth

Sus observaciones adicionales son bienvenidas y por favor escribalas aquí.

The courses should be closer together, improve the logistical support.

APPENDIX D

LETTER OF THANKS TO SEMAPA

Cochabamba, 30 de julio de 1986

Señor
Ing. Roberto Prada Ramírez
GERENTE GENERAL
"SEMAPA"
Presente

Estimado Ingeniero:

WASH, USAID y DSA, están colaborando a dar una serie de cursos en el aspecto de operación y mantenimiento. Estos cursos son para mejorar y fortalecer las actividades de operación y mantenimiento en DSA y sus comunidades.

Desde el 14 de julio hasta el 1° de agosto se está dictando un curso sobre la operación y mantenimiento de bombas para sistemas rurales de agua. SEMAPA ha ayudado a llevar a cabo un curso de mejor calidad para los técnicos, quienes trabajan para DSA; la mayoría de la región del país, también ha contribuido con su tiempo, sus equipos y herramientas incluyendo una visita y explicaciones de la planta de tratamiento.

Para concluir quiero manifestar que la compañía WASH a través del programa de USAID, desea dejar patente nuestro agradecimiento por la colaboración prestada de las siguientes personas incluyendo a usted.

Ing. Enrique Guilarte, Sub-Gerente
Ing. Orlando Villarroel
Ing. Julio Vargas

Sin otro particular, aprovecho la oportunidad para saludarlo atentamente,

Amy A. Titus
Consultora, WASH

gus
cc.