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WASH

WATER AND SANITATION FOR HEALTH PROJECT

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OPERATION AND MAINTENANCE OF RURAL WATER SUPPLIES IN THE YEMEN ARAB REPUBLIC

WASH FIELD REPORT NO. 259

MARCH 1989

Prepared for
the USAID Mission to the Yemen Arab Republic
WASH Task No. 015

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by

Jonathan Hodgkin

March 1989

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ACRONYMS

CPO	Central Planning Organization
CLCCD	Confederation of Local Councils for Cooperative Development
CYDA	Confederation of Yemeni Development Associations
JICA	Japanese International Cooperative Assistance
LCCD	Local Councils for Cooperative Development
LDA	Local Development Associations
MAF	Ministry of Agriculture and Fisheries
NTF	New TransCentury Foundation
NWSA	National Water and Sewerage Authority
O&M	Operation and Maintenance
RWSD	Rural Water Supply Department
SURDP	Southern Uplands Rural Development Project
TDA	Tihama Development Administration
UNCDF	United Nations Capital Development Fund
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Fund
WHO	World Health Organization
YAR	Yemen Arab Republic

9.75 YR (Yemeni Rials) = $ 1.00 US) official rate
11.2 YR (Yemeni Rials) = $ 1.00 US) market rate

EXECUTIVE SUMMARY

Introduction

A number of water supply systems installed under USAID/Yemen's Small Rural Water Systems Project have been found, according to some reports, inoperative less than a year after the completion of the project. USAID and the Confederation of Local Councils for Cooperative Development (CLCCD), interested in assisting local councils and rural villages in improving the operation and maintenance of their water systems, have proposed corrective action under an activity to be funded under PL480 (Title I). A WASH consultant completed a four week study (January 19-February 15) of operation and maintenance practices to formulate a plan for increasing the reliability of rural water supplies and establishing O&M workshops in several regional centers. The consultant conducted interviews with government officials, officials of the CLCCD, other donors, private sector entrepreneurs, and village pump operators. The consultancy included a seven day field trip to 29 villages in Dhamar and Hodeidah governorates.

Findings

Rural water systems are installed by the Rural Water Supply Department (RWSD), usually with donor assistance, by the Ministry of Agriculture and Fisheries (MAF) as part of larger development projects, or by Local Councils in collaboration with villagers who typically cover 25-30 percent of the cost with either cash or in-kind contributions.

Once completed, these systems are handed over to villages and the operation and maintenance responsibilities devolve on the villagers themselves. The RWSD has no operation and maintenance responsibilities, and although the local councils have the mandate to assist in solving problems relating to development projects, this falls short of taking responsibility for water systems. Some, but not all local councils occasionally provide funds for the timely repair of inoperative water systems.

Villagers have their own ways of handling the operation, maintenance, and repair of their water supply systems, some more effective than others.

Typically, the pump operator is not well trained and major repair problems develop as a result of poor operation and maintenance practices and poor completion of minor repairs. A common feature of all village arrangements is heavy reliance on private sector mechanics and workshops to evaluate and perform some minor and all major repairs. These tend to be expensive and require that villagers raise funds to cover the costs.

Rural water supply systems are typically out of service for three main reasons, only one of which can be addressed through improved O&M. These reasons are:

- Community conflict (usually arising from differences over responsibility or payment)
- Inadequate water sources (arising from poor choice of well site or overpumping of the aquifer)
- Operation and maintenance problems.

Villagers make distinctions between minor problems they feel they can solve easily and major problems which are more difficult to deal with. Major repair problems occur on average once a year and take three weeks or a month to fix. During this time, villagers return to traditional water sources, purchase water, or obtain it from irrigation channels. In many cases inadequate attention to O&M and performance of minor repairs contributes to these higher than necessary major repair frequencies. However, just as important as the frequency of repair is the length of time the system is inoperative. Much of the down time is spent in raising the funds to complete the repair.

The private sector is active in providing repair services to rural villages. Local mechanics for minor repairs, mechanics from district or governorate centers for more serious problems, and occasionally mechanics from the equipment agents for particularly difficult problems are always available. But, except for the local mechanics, their services are expensive.

Villagers are free to collect funds and arrange for operation, maintenance and repair in any way they wish. Most raise funds for fuel and oil, the wages of the operator, and minor repairs by assessing villagers 15 YR to 30 YR per household per month[1] or by charging for metered water. These funds should be sufficient for operation and maintenance and most major repairs. However, this does not appear to be so, either because recordkeeping is lax or the rate of assessment is not high enough.

Major repairs require locating a mechanic and getting him to provide a list of required parts and an estimate of the total cost. The village then raises the funds from each household and arranges to obtain the parts from the equipment agent or a nearby subdealer. Only when the funds have been collected and the parts purchased does the mechanic return to complete the repair.

The capability and interest of the local councils depend heavily on the personalities and capabilities of the elected officials. A number of local councils take no active part in the water affairs of district villages, and few if any, provide direct service support. In most cases, the LCCDs are asked to provide funds for repairs. The local councils responsive to these needs are vulnerable to pressure from villagers.

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[1] 9.75 Yemeni Rials = $1. US (official rate of exchange)

Conclusions

The five major conclusions from the findings are as follows:

- The maintenance of rural water supplies is not as bad as originally feared. Community conflict and inadequate water resources also contribute to the total of inoperative systems. An estimated ten percent are out of order at any one time due to O&M problems.

- The private sector does an adequate job of providing services (in the form of spare parts and skilled mechanics) for engine and pump repair. Highly skilled mechanics are available in urban areas and do travel to service equipment in rural villages. However, the local mechanics used for minor servicing and repairs are not as likely to be well trained.

- The major obstacle to overcoming the O&M difficulties of rural village water supplies is the availability of revenue for making unexpected major repairs.

- Improved operation and maintenance practices would reduce the frequency and severity of water system breakdown and increase the availability of potable water.

- The local councils are best suited to assist by providing training for pump operators, but without taking responsibility for water systems.

Recommendations

USAID should endorse a CLCCD program to support local councils by providing water system operation, maintenance and minor repair training for pump operators. Care should be taken to assure that villages continue to be responsible for the operation, maintenance and repair of their own water systems and that the local council does not become involved in the direct provision of O&M services to rural villages. The major activity recommended is to encourage the establishment of a pump operators training unit at the CLCCD branch office level. This unit would be capable of conducting pump operators training courses both at the CLCCD branch office location and at selected local council locations within the Governorate. These training units should be established as part of USAID's overall PL480 support to the CLCCD. Foreign exchange funds should be made available for the purchase of tool kits for the operators' completing training, for training aids and possibly for short term training for the training unit staff. The training course should be subsidized by the CLCCD as an investment in the long term benefits of reduced repair and replacement of equipment.

This program should initially focus on one CLCCD branch office location and seek to provide a demonstration pump operators training course which could be replicated at other locations. Future expansion of the activity to other locations should await the successful establishment of activities at the first CLCCD branch office. This program will serve as a pilot for future activities which will not necessarily be funded by USAID or with PL480 funds. Such a pilot program would increase the availability of potable water and reduce the number of inoperative rural water supply systems.

Chapter 1

INTRODUCTION

1.1 Problem Statement

In late 1988, USAID/Yemen ended its fifteen-year support to the Rural Water Supply Department (RWSD) with the completion of the second phase of the Small Rural Water Supply Project (project 044). The preliminary findings of a survey of 102 project sites during the year by Dr. Abdo Ali Uthman (Dept. of Sociology, Sana'a University) raised questions about the villagers' ability to operate and maintain these water supply systems and confirmed information from several other sources, that a large number of them are probably not operational for indefinite periods of the year. Because of its large capital investment in these water systems, USAID/Yemen requested the WASH project for assistance in devising a strategy to address the operation and maintenance needs, not only of these systems but of all rural water systems in Yemen.

WASH assigned Jonathan Hodgkin of Associates in Rural Development as the consultant to undertake this work. He arrived in Yemen on January 20, 1989 and presented his findings and recommendations to the mission on February 13, 1989. He was assisted by Mr. Robert Mitchell, USAID's general development officer, and Mr. Mohammed Abdul Kader, the general development program assistant.

1.2 Scope of Work

The purpose of the consultancy was to assist USAID and the Confederation of Local Councils for Cooperative Development (CLCCD) with a plan for increasing the reliability of rural water supplies and establishing or strengthening operation and maintenance (O&M) workshops in several regional centers. The plan was to fit into the decentralized community development program being developed with the CLCCD, and to be largely supported by PL480 (Title I) local currency funds.

The scope of work (see Appendix B) outlined seven tasks for the consultant:

1 - to prepare a specific strategy and implementation plan to provide O&M services in support of rural water projects in cooperation with and under the supervision of the CLCCD and involving, to the maximum extent possible, the private sector (addressed in Section 5.3),

2 - to prepare a list of tools and equipment required by the CLCCD's proposed O&M service centers (US$ 150,000 is available for procuring this equipment)(Appendices H,I, & J),

3 - to prepare other specifications for the O&M workshops, including the space they will require (Appendix B),

4 - to prepare a staff pattern and staff training program for the centers (Section 5.4),

5 - to prepare administrative and billing procedures for handling the services to be provided by the centers (Section 5.4),

6 - to prepare a proposal for USAID's technical assistance to and management of the O&M services component of the proposed follow-on PL480 activity (Section 5.5), and

7 - to provide other recommendations to USAID and the CLCCD for the development, implementation and management of this O&M effort (Chapter 5 and relevant appendices).

During the course of the consultancy it became clear that the SOW focus on O&M workshops may have been misplaced. The consultant was asked to examine the need, potential and strategy for an operator training program. This information is included in Chapter 5 as part of this report.

1.3 Approach

The consultant made field visits to both operational and nonoperational water supply systems to gather information on operation, maintenance, and repair practices and to interview USAID officials, CLCCD and local council officers, pump operators, village water users, private sector individuals, and donor representatives for an overview of current infrastructural arrangements, and the potential for sustainability. The suggested plan is based on the obvious need for improved O&M and the limited capacity of the LCCDs. The following chapters provide the background to water development in Yemen; current operation, maintenance, and repair practices; and recommendations for future action.

Chapter 2

BACKGROUND OF WATER DEVELOPMENT IN YEMEN

2.1 Physical Setting

The Yemen Arab Republic covers an area of approximately 75,000 square miles (see map) in the southwest corner of the Arabian peninsula. The country is roughly divided into three geographical areas: the Tihama coastal plain extending about 60 km from the coast, with elevations from sea level to 1,500 meters; the highland area with elevations up to 3,700 meters; and the eastern slope with elevations tapering off to 100 meters. According to the 1986 census the official population is 9.3 million, making Yemen the most populous country in the peninsula. Some 1 million Yemenis are working abroad, largely in the Persian Gulf region. About 80 to 85 percent of the resident population lives in rural areas in towns, villages, and settlements, and roughly 20 percent of these rural dwellers have access to improved water supplies. Income for rural-dwelling Yemenis comes largely from agriculture and remittances of workers abroad, although this latter source has decreased in importance in the last several years.

2.2 Water Sources and Water Pumping Technologies Used

Availability of water has always been limited. Traditional water sources include surface water found in shallow wells in wadis, weak springs, or large run-off catchments or cisterns. Over the past 15 years there has been an enormous growth in the use of diesel engines to pump water from boreholes or dug wells. It is estimated that 4,000 to 5,000 diesel driven systems serving potable water needs in rural areas have been installed as a result of government, donor, and local self-help initiatives. In some areas, privately owned water systems have also made a contribution.

Diesel driven pumps are now used almost exclusively in improved water systems. There does not appear to be any single agreed upon technical design standard among the three government agencies most active in providing public water systems the RWSD, the CLCCD and the Ministry of Agriculture and Fisheries (MAF). However, three main configurations for pump and prime mover are in common use: belt driven vertical turbine; shaft driven vertical turbine; and generator driven electric submersible.

The belt driven vertical turbine is in use in wells up to 75 meters deep and is popular in the Tihama region. It is also used in other areas where conditions permit. Engine sizes vary from 16-50hp. In deeper wells, with pump settings of up to 175-200 meters, shaft driven vertical turbine pumps are used along with engines equipped with clutches. These are more common in mountainous regions and to some degree in the central highland valley. Beyond 200 meters lift, diesel driven generators coupled with electric submersible pumps are commonly used and are becoming more popular for RWSD installations. Although as recently as five

years ago the diesel driven electric submersible was rare, roughly 20-25 percent of new installations use this configuration.

At the surface, the works include ground reservoirs, elevated tanks with distribution systems, and either public or private connections. Older systems installed with design and financial assistance from the cooperative movement (now represented by the CLCCD and the local councils) are likely to have ground tanks, with users coming to the well site to obtain water. Recently, many of these systems have been upgraded to include an elevated reservoir, usually of reinforced concrete. Current RWSD designs all include elevated tanks or ground tanks situated above the users to allow for a pressurized distribution system and private connections. Current distribution design is intended to allow the use of private connections (either metered or not depending on village policy), for which users must pay the installation costs in most cases. Public taps in central locations serve users without private connections. Most users prefer private connections, and there are a number of villages where all households are privately connected to the distribution line.

The use of booster pumps is fairly widespread in the mountainous areas, where generally villages are situated on ridges, and wells in the valleys some distance below. Vertical turbine pumps are commonly used to bring the water from a well-head reservoir to a reservoir above the village (which may be an elevated tank).

2.3 Operation and Maintenance Ramifications

The more complex the system the greater the O&M requirements and the probability that difficulties will occur. Belt driven vertical turbines are the simplest. Shaft driven systems introduce a clutch mechanism and an additional complexity. But both of these are mechanical and require only the skills of a qualified mechanic for maintenance and repair.

Generator driven submersible pumps introduce an electrical generation and control element which requires the skills, of not only a qualified mechanic but also a qualified electrician. Electrical skills although not unknown in rural areas, where there are numerous privately owned generators, are likely to be less common. Control system problems then will drive villagers back to agents in the major urban areas and repairs will most certainly be much more costly. The use of electric submersible pumps is dictated by the maximum head capabilities of vertical turbine pumps and the requirement that boreholes be straight for their trouble-free operation. They have not been in widespread use for very long, and to date it appears that the problems with them have been minor. However, in the future, maintenance and repair of these systems will no be easy for villagers.

The use of booster stations, dictated by topography, increases O&M requirements and potential difficulties in proportion to their numbers. As long as they are configured with vertical turbine pumps, they are no more troublesome individually than other vertical turbine installations. However, the use of one in a water supply system doubles the O&M requirements and the vulnerability of the system as a whole.

2.4 Central Government Activities

From 1918 to 1962, Yemen was governed by the Zaydi Imams as a feudal state with little or no influence from the outside. The last of these, Imam Mohammed Badr, was overthrown only a week after the death of his father, Ahmed. However it was not until the end of the civil war in the early seventies that the task of modernization really got underway. The RWSD of the Ministry of Public Works was formed in 1972, and the National Water and Sewerage Authority (NWSA) was formed in late 1973. Over the years, the Ministry of Agriculture and Fisheries (MAF) has also been involved in the water sector, both for irrigation and for village water supply systems.

Rural Water Supply Department

The RWSD, whose role is to install water systems in rural areas, has been supported over the years by a number of large donor projects, including the USAID funded 022 and 044 projects. The RWSD organization includes a project department, a mechanical department, and a hydrology department, which together provide groundwater sources by drilling boreholes, design water systems, and supervise construction. The RWSD has a staff of roughly 60 people. Only a few of these are fully qualified Yemeni engineers; the rest are expatriates working on support projects. From the beginning, the construction of water systems has been contracted out to sector firms. Over the past several years, an increasing amount of the drilling work has also been contracted out until it appears now that the RWSD no longer does any drilling itself. It has no overall plan of operations and few formal procedures, and measures its success in terms of water systems installed, not systems currently operating, and the number of people served by them. The RWSD has constructed more than 1,075 systems through 1988 by its reckoning.

Although the RWSD is not responsible for the operations and maintenance of systems it has completed, and does not construct all water systems, its methods of operation have an impact on O&M issues at the village level. It has installed most of the electric submersible pumps, with their potential for trouble described earlier. In addition, the tender process for procurement of engines and pumps precludes standardization and results in a wide range of equipment from different manufacturers, with little consideration of local skills or the availability of spares.

In late 1988, the RWSD was transferred to the Ministry of Electricity and Water. RWSD officials indicate that this may be in preparation for upgrading it to an Authority. As an Authority, it would have the financial flexibility to borrow money to complete projects, and to increase the salaries of technical staff. If this change takes place, the RWSD could be given some O&M responsibilities.

National Water and Sewerage Authority

The National Water and Sewerage Authority (NWSA) is essentially a parastatal organization. In theory, NWSA has overall responsibility for all water supply and sewerage systems in the country. In practice, it has focused on systems in urban areas. As such, it continues to be responsible for operation and maintenance of these systems, and collects fees, in accordance with directives from the national cabinet, to cover O&M as well as debt servicing. In several cases, very complex village water systems, including multiple booster stations, have been transferred to NWSA for operation and maintenance. This is not a common practice today, but may increase somewhat in future.

Ministry of Agriculture and Fisheries

The Ministry of Agriculture and Fisheries (MAF), through the Tihama Development Authority (TDA) and the Southern Uplands Rural Development Project (SURDP), has also provided rural water systems as part of its overall development activities. But these organizations take little or no interest in the operation and maintenance of these systems once they are completed, leaving these tasks to the villagers. The Dutch-supported Radaa Integrated Rural Development Project, active in Al Beida Governorate over the past decade, has installed water supplies as part of its activities. It recently established a mobile workshop unit with the primary purpose of training village pump operators. Through the first six months of its existence the mobile unit has been engaged in maintenance and repair operations and the training aspect has not been given much attention.

2.5 The Cooperative Movement

The cooperative movement had its beginnings during the period following the overthrow of the Imamate. During this period of civil unrest from 1962 to 1970, local organizations sprang up to meet the needs of communities. By 1972 these organizations had developed into full-scale self-help organizations harnessing local resources for local development. In 1973, the central government, realizing that it did not have the resources to extend government services to much of the rural countryside, encouraged legislation that put these organizations on a firm legal footing. Known as Local Development Associations (LDAs), they were to be administered by the Confederation of Yemeni Development Associations (CYDA) under the Ministry of Social Affairs, Labor, and Youth. The focus of LDAs has been on rural infrastructure including water supply and feeder roads, primary schools, and health facilities. The administrative structure of the LDAs consisted of general representation at the village level, a body of elected officers at the district level, an administrative body at the governorate level, and the national office of CYDA. Only the village level representatives were elected by popular vote, the higher level positions being filled by vote among the members elected at the next lower level. The LDA remained the basic unit for project activity. LDA funding came from the traditional "Zakat" Islamic tax and a number of other special taxes. Projects were jointly financed from LDA funds and contributions in kind or capital from

the village or villages directly benefiting from the project. A large number of water projects have been implemented in this way.

In 1985, a restructuring of the local council system resulted in the creation of the Confederation of Local Councils for Cooperative Development (CLCCD) in place of CYDA, and Local Councils for Cooperative Development (LCCD) or more commonly local councils at the LDA level. The stated purpose of these changes was to allow better coordination of local council activities with the activities of the line ministries (which work in parallel in certain sectors, including installation of rural water supplies). These changes have had a series of direct and indirect effects. The current structure retains much of the form of the previous system but has changed it in some fundamental ways. At the local level, the LCCDs were realigned to conform to the government sub-district (Nahiya) structure (see Figure 1, Appendix L). As such, there are now 216 local councils. The local council system does not have offices at the government district level. At the governorate level, the council system maintains regional branches of the CLCCD rather than the full independent regional entity which existed previously. At the national level the secretary general of CLCCD is now an appointee with an elected assistant.

Before the reorganization, planning took place at the LDA level and project funding came from local revenues, giving the LDA wide powers to plan and implement projects in response to locally expressed needs. The planning process now requires the LCCDs to develop one-year and five-year plans which are passed up through the council bureaucracy and must be approved by the Central Planning Organization (CPO) to ensure that they are in concert with national development strategies. On the financial side, funds originally retained at the LDA level must now be forwarded to the district office of the Ministry of Finance to permit the funding of projects in accordance with CLCCD and CPO priorities. This, it is argued, will help rectify regional imbalances in development and allow more coordination between central government and council activities. But these changes have reduced the ability of the local councils to respond to local needs and have undermined the confidence of the villagers in these organizations.

The effectiveness of LCCDs and LDAs is dependent on many factors, not the least of which are the interest and competence of elected officials and the support of the sheiks in areas where tribal systems remain strong. The LCCDs are indeed responsive to villagers' needs in many districts, focusing chiefly on education, road construction, and health (see Table 1, Appendix L). Water sector activities, most of them new projects, accounted for roughly 15 percent of the CLCCD budget in 1986, the most recent year for which data are available (see Table 2, Appendix L). Maintenance and rehabilitation included upgrading systems with elevated tanks, drilling new wells where necessary, as well as some ongoing maintenance, repair, and replacement of system components.

In many subdistricts, the LCCDs are responsive, within their means, to requests from villagers for assistance in establishing improved water delivery systems, particularly where the RWSD or donors cannot be prevailed upon to help. Often the LCCD will provide a borehole, and the villagers, the pump and engine, or the LCCD may pay half the cost of an elevated tank. It is not entirely clear how

LCCD priorities are determined or if there is a set formula for village participation.

Almost universally, villagers pay the operation and maintenance costs of their water systems and the salary of an operator. Many LCCDs retain an interest in the functioning of water systems in their area and have devised various mechanisms to continue their support when the villagers cannot marshal the resources. Larger repairs and replacement of larger system components such as pumps and engines are largely beyond the financial ability of villagers. In these cases an appeal to the LCCD is common.

A summary of organizations and their responsibilities for each of several activities within the water sector is provided below.

Responsibilities by Organization For Various Water Sector Activities

	Planning	Drilling	Funding	Installation	O&M
NWSA[1]	X	X	X	X	
RWSD	X	X[2]	X[3]	X[2]	
CLCCD	X	X	X	X	
LCCD			X	X	
MAF	X	X[2]	X	X[2]	
Villages	X		X[4]		X
Private sector		X		X	X

1 NWSA activities are largely limited to urban water supply.
2 Activity is largely responsibility and supervision of private contractors.
3 Significant funding is provided through donors.
4 Villages provide funding for O&M and in some cases financial or in-kind contribution for installation.

2.6 Donor Activities

USAID

USAID has supported water sector activities since 1973. Shortly after the formation of the RWSD, USAID funded project 022, designed to strengthen the new agency by helping establish well drilling, mechanical, and workshop/warehouse sections. Project activities also included drilling wells and improving about 10 rural water supply systems annually. As have later USAID projects, project 022 incorporated a substantial self-help component.

In 1978, it was followed by the 044 Small Rural Water Supply Project, much larger and more ambitious in its intent to increase the RWSD's capabilities to:

- Plan, survey, budget, and design rural water systems
- Construct rural water systems in conjunction with the local development associations, villagers, and the private sector
- Train villagers in the operation and maintenance of rural water systems and teach them the public health benefits of clean water
- Seek ways of increasing village contributions and foreign donor support.

More than 170 water systems had been installed by the end of the project in late 1988, but largely in turnkey fashion without significant institution-building taking place at RWSD. Thus, about 220 people were trained from 1985 to 1987 under an operator training program offered to villages receiving RWSD support for water system construction. Unfortunately not all went on to become operators for water systems in their villages. A similar WHO supported program in place from 1980 to 1983 trained about 160 pump operators, who took a comprehensive one-month course offered in Sana'a.

USAID also funded the 028 Yemen Water Supply Systems Project, early in water sector development, in support of the newly created NWSA. But the objective of extensive institution-building assistance to NWSA was largely overshadowed by the day-to-day activities of the capital improvement program then underway.

Project 045, the Integrated Rural Development Project, implemented through CYDA and LDAs in the Hodeidah and Hajja Governorates, also installed eleven water supply systems in Hodeidah and two in Hajja. A mobile workshop was placed in Hajja and a training course was run for operators of heavy road equipment. In addition, the Yemeni mechanic provided on-the-job training (OJT) to the operators when he was repairing equipment. This component improved operations skills and reduced the downtime of this equipment during the period the workshop was in use. This activity stopped shortly after the completion of the 028 project and the CLCCD is now trying to revive some aspects of it.

United Nations Affiliated Agencies

The World Health Organization (WHO), the United Nations International Children's Emergency Fund (UNICEF), the United Nations Capital Development Fund (UNCDF), and the United Nations Development Program (UNDP) have all been involved in rural water supply in Yemen. WHO support to RWSD includes technical assistance in surveying, drilling, and the supervision of contractors. The present project manager has been in Yemen for almost eight years and there have been two before him. UNICEF is the executing agency for three projects with RWSD all scheduled for completion in 1989. In conjunction with the Ministry of Health, it has participated in the construction of 30 water systems annually. It is also

participated in the construction of 30 water systems annually. It is also overseeing a UNDP/UNCDF project to provide commodities (pumps, engines, pipes, etc.) for more than 40 systems, the last ten of which are now ongoing. The third project is the management of Swiss support for ten water systems, now reduced to seven.

Other Donors

The Saudis, the Kuwaitis, the Japanese, the Germans, and the Dutch have all contributed to new water projects. Most of these contributions have been made through RWSD in turnkey fashion or have provided commodities. Current contributors include Saudi Arabia, Japan, and the Netherlands. All past projects, except the USAID project, received little or no contribution from villagers. The USAID model requiring village participation has now been adopted by the Dutch. A summary of all projected donor assistance to RWSD through the present plan period (1987-1991) is provided in Table 4 (Appendix I).

A number of organizations such as Catholic Relief Services, Irish Concern, the Peace Corps (in support of project 045), and UNDP have supported various CYDA water projects. The magnitude of assistance has been much less than to RWSD. There is some additional donor support for establishing water projects outside RWSD and CLCCD. The most notable of these is the Dutch-supported Radaa Integrated Development Program in Al Beida Governorate which has installed more than 80 water systems during its more than 15-year life.

2.7 Private Sector

The private sector is very active in contracting services, provision of equipment, repair services, and drilling. RWSD now contracts all of its drilling and much of water system construction to the private sector, and a major part of its activity is the supervision of contractors and monitoring the quality of their work. The well drilling, borehole completion, and test pumping by some firms have suggested the need for more careful monitoring of contracts. However, there are currently five or six contractors capable of complete installation of a water system, including pump, engine, tank, and distribution systems, to good standards. The 044 project contributed to upgrading the skills of some of these contractors and provided training to RWSD technicians in construction supervision.

CLCCD has a number of drilling rigs in poor condition (six fifteen-year-old Ingersol Rands recently donated by RWSD), so its capacity to drill wells is limited. Besides its budget for this section is limited, and it lacks many of the most basic spares and tools. As a result, the local councils contract directly with area private sector drillers. These rigs are often old, barely serviceable cable tool rigs. The councils also contract with local or regional private sector firms for installation of pumps, engines and tanks (to specifications developed at the council level or at the regional CLCCD office).

The Yemeni private sector is the source of most of the engines, pumps and materials used for construction and maintenance of water systems. Most equipment

for construction is let for local tender and is not imported directly by donors. This has minimized the makes and models for which spare parts cannot be procured. However, there are a number of trading houses that sell engines (Yanmar, Kubota, Mitsubishi, Fiat, Lombardini, Hatz, Lister/Petter), vertical turbine pumps (Alta, Rotos, Ebara, Saba, Arita, Porecelli), and submersible pumps (KSB, Pleuger, Grundfos). The larger of these importing agents have branches and subdealers in all major towns and urban centers, providing a network through which new equipment and spare parts are available all over the country. But prices are often high due in part to the more than 20 percent customs duty and the defense tax on imported items. As a result, there is a ready market for Taiwanese and Korean copies of genuine spares and some smuggling of parts from Saudi Arabia.

The major importing agents provide repair services for the equipment they sell. Field servicing costs as much as 600-1000 YR[2] per day (not including overnight per diem for longer jobs). But the quality of work is good and is recognized as such. Villagers will avail themselves of these services when they perceive that local mechanics cannot manage the work. There are other workshop facilities in the country providing field support and overhaul services. The better of these are in Sana'a, Taiz, and Hodeidah. Smaller less well-equipped workshops exist in almost every district. Mechanics working out of their homes with limited tools and no workshop space are available in many smaller villages, and it is these men who provide the first line of support to rural water systems.

Also using the support system described in the preceding paragraphs are the many private pump owners, of whom there are said to be several thousand in the Tihama region alone. They are also found in the highlands, even though well drilling and pumping costs are higher. These private owners probably constitute the largest segment of the private sector pumping business. Private well owners often sell or provide water at no charge (depending on circumstances). In some areas that have no water system or none that is operational, large tanker trucks deliver water for a fee. In the Tihama, families often obtain their water from the large number of irrigation channels.

[2] 9.75 Yemeni Rials = $1 US (official exchange rate)

Chapter 3

CURRENT OPERATION AND MAINTENANCE PRACTICES AND STATUS

Water supply systems do not always cease operating for technical reasons, and even where technical problems occur, there are a number of possibilities, all calling for different remedies. This chapter will discuss these factors as well as what villagers do to keep their water systems operational.

3.1 Observed Reasons for Inoperative Water Systems

A significant number of rural water supply systems are out of order at any given time. A survey of USAID-funded water projects, conducted by Abdo Ali Uthman of Sana'a University, found about 25 percent of the systems were not working. A similar study by the Dutch indicated that 26 percent were nonoperational. Yet another study by Mullick, Socio-Economic Aspects of Rural Water Supply and Sanitation-A Case Study of the Yemen Arab Republic, suggests that 30-35 percent of completed projects are not functioning for want of repairs, spares, or funds. During a field visit to one subdistrict of Hodeidah Governorate, the consultant found 15 out of 52 (or 29 percent) of water systems were not operating.

There are three major reasons for non-operational water systems:

- Community conflict
- Inadequate water sources
- Operation or maintenance problems

There are no definitive numbers to rank these three in order of significance, but informal surveys have yielded some useful data. A Dutch survey conducted in the Radaa project area (before the introduction of the mobile workshop mentioned earlier) found that, of eleven nonoperational systems, one could be attributed to village conflict, seven to inadequate water sources and three to O&M difficulties. The consultant's experience in 18 villages was that of six nonoperational systems, two could be attributed to community conflict, two to inadequate water sources, and two to O&M difficulties. This information suggests that perhaps 33 percent of all inoperative systems (or 10 percent of all systems) are out of order as a result of O&M and repair difficulties at any one time.

Community conflict can arise in several ways. In one case, several villages connected to the same system were unable to agree on the apportionment of responsibility and costs. In other cases, alternative water sources were available and the villagers did not seem to value the system enough to cooperate. There may also be opposition to the public water system if powerful individuals within the village stand to gain, perhaps by providing water from

private sources. These situations often arise when villagers cannot agree on how to make the necessary repairs to mechanically inoperable systems. But the resolution of these difficulties requires more than spares and skilled labor and falls outside the normal scope of operation and maintenance.

Inadequate water sources are relatively common for two reasons: aquifers are being overpumped in a number of areas and water levels are dropping. Water sources are poorly identified in the initial phase of a project. Villagers, often with the assistance of the local council, do eventually address these problems by deepening wells or drilling new ones. However, these are not operation and maintenance problems and are normally categorized as rehabilitation.

Operation and maintenance difficulties arise for a number of reasons which are discussed in the following section.

3.2 Potential Operation and Maintenance Difficulties

Operation and maintenance difficulties can arise from shortages of:

- Fuel and oil for operation
- Spare parts, either in the country or at the local level
- Skilled mechanics
- Financial resources
- Well-trained operators

Yemen is now a crude oil exporter (some 100,000 barrels/day) from recently developed oil fields east of Marib. About 70,000 barrels are refined and used within the country. Diesel fuel and lubricating oil are not difficult to obtain, prices are fixed countrywide, and supplies appear to be available in all towns and urban areas. Fuel is also available at isolated stations along major roads.

The availability of spare parts is to some degree a function of the make and model of pump or engine being used. The fast-moving spares (defined by one supplier to include pistons and crankshafts) for most Japanese engines are plentiful. Spares for German, Italian, and British engines are also available. However, spares are expensive because of more than 20 percent in import and customs duties. Taiwanese and Korean copies of genuine parts are available on the market for 20- 25 percent less than the original, and smuggled spares can also be found. As mentioned previously, most major importers have branch offices and subdealers throughout the country. For the most part, therefore, it does not appear that the availability of spare parts is a major problem, except for uncommon equipment or odd spares.

Mechanics are available in almost all rural areas. Some of these are likely to be self-taught but several have received training while working in the Gulf region or for companies or agencies within Yemen. Not all these mechanics may be very good. Villagers turn to them for minor repairs and sometimes for more complex repairs. But generally the more complex mechanical tasks, such as engine overhauls and more difficult trouble shooting, send villagers to urban areas, often to the importing agent, for assistance. Mechanics in importing agents workshops are usually well-trained but expensive. Thus, there is no major shortage of skilled mechanics in the country, but their cost and ready availability in rural areas are a problem.

So also are financial resources. The funds collected by villagers for the operation and maintenance of their water system rarely provide a reserve. When repairs are necessary, villagers are asked to contribute lump sums based on repair costs. When questioned they will explain that it took some weeks to collect the money but only a day or two for repairs, an indication that a lack of readily available financial resources is a major obstacle.

There is considerable evidence that poorly trained operators contribute to operation and maintenance problems. Field visits revealed dirty engines and leaking oil. Operators explained that their only duties were to start and stop the engine and add oil. This was not universally true, however, because among those interviewed were several who had participated in the WHO- or Project 044-sponsored training programs or had had prior training elsewhere. But in general, there appears to be little or no appreciation for preventive maintenance in any form beyond oil changes and even these at extended intervals. Interviews with overhaul workshops in Sana'a indicate that oil related problems account for most of their overhaul work.

3.3 Village Approaches to Operation and Maintenance

Villagers obtain water supply systems through RWSD, their local councils, and MAF. However, in all but a very few cases, the responsibility for operation and maintenance is theirs. Since they are given no guidance, they have evolved their own forms of management. This section describes the most common management practices and the salient features of each.

Village responsibility begins with the handing over of the completed system to the LCCD representative or the village sheik. Since money is required for operation and maintenance, the first priority is agreement on the method for collecting funds. A pump operator is selected, and in some cases a water committee is elected to oversee this initial organizational process. In others, one or several villagers will take this task upon themselves. Funds are usually collected from each household, the monthly sum ranging from 10 YR to 40 YR ($1-$4 US) per household, with assessment on a sliding scale according to ability to pay. In some villages payment is per person, with a range of 3 YR to 7 YR ($.31 - $.72 US) per month. Some villages have installed water meters and charge according to consumption. Fees in these cases range from 5 YR to 10 YR ($.50-$1.00 US) per cubic meter. If all funds are collected and utilized for O&M and repair, they should be sufficient to cover almost all costs.

The pump operator is likely to be selected from among the most knowledgeable and available males. Although WHO and the USAID 044 project have trained some pump operators and a number may have worked outside the village at some point, it is unlikely that the operator will have had any formal training. Funds for O&M are often collected by the operator or by a clerk who is responsible for this task. Given the water use fees, there should be some money available after the operator is paid (600 YR to 1500 YR per month) and the fuel and oil purchased. There is not always a detailed accounting of how funds are spent. Management and control of funds and operation of the system seem to lie heavily on the pump operator.

In a smaller number of cases, where a committee has been elected and meets periodically, villagers take a more active interest and accounting for funds is likely to be more rigorous. A larger maintenance and repair budget seems to be available in these villages. In several districts, the local council gets involved in the operation of water systems, providing a subsidy of 15 to 20 percent for normal O&M and minor repairs. This, it was explained, was because the villages in the area could not afford even the normal O&M costs.

Pump operation is normally left pretty much to the pump operator. He starts and stops the engine (sometimes several times a day if the well yield is not high or the storage tank small) and changes the oil periodically. He is generally responsible for repairs to the distribution system and for some minor engine repairs or for arranging repairs he is unable to do himself. In many cases, he is called upon to assess the seriousness of problems (but not necessarily to diagnose them) and contact a mechanic he believes is capable of handling the repair. For larger repairs, he gets estimates of the cost. Sometimes this is done by the water committee, which approves and oversees various expenditures for repair. However, in most cases operation and repair are left to the discretion of the operator. In at least one case, there was no designated pump operator, and anyone who was able could add fuel and start and stop the engine. Preventive maintenance (beyond changing the oil) is not normally considered part of an operator's duty, though in some observed cases the engines were clean and well cared for. When asked about tools, most operators said they had none or very few.

Villagers and pump operators seem to make a distinction between minor and major repairs, but it is not clear what this distinction is. There appear to be three possibilities for a definition of major repairs:

- Repairs require the services of a mechanic who is not readily available.
- Repair costs exceed the village's reserve fund and additional funds must be collected.
- System outage exceeds some unspecified period of days, creating hardship for the villagers.

The actual definition probably includes aspects of all three. However, in all cases, minor repairs (by whatever definition) are not considered a problem. Repairs that seem to fall in this category include pipeline repairs, splicing of drive belts, bleeding air from the fuel line and, depending on the village, such things as checking injectors or decarbonizing the engine.

The concept of major repairs is much more complex. In most cases it appeared that they cost 3,000 YR or more, required a mechanic from a town or urban area, or took several weeks. Examples of what are considered major repairs are pump replacement, internal engine repairs, and engine overhauls (often performed in the field without reboring or resurfacing heads). Major repairs, as defined by the villagers, are required at least once a year and occasionally more often than that. This is a high repair requirement, given the relatively new engines and their use. The quality of care by the pump operator and the quality of minor repair servicing are obviously significant. Money appears to be the primary difficulty in village response to major problems. If RWSD installed the water system, an appeal for assistance might be made to RWSD officials who, unless the villagers had a government connection, would be unlikely to take notice. Appeals to the local council might also be made, with the likelihood of success dependent on the strength of local council management and the involvement of the local council in the water activities of district villages. In several districts visited there appeared to be no local council interest in the water affairs, but, in several others, the interest and involvement were obvious. In almost all cases, villagers collected at least some of the funds for major repairs.

Once the funds have been obtained, the spares are purchased, either in the next larger town or from the import agent or the branch office in the Governorate capital, and the mechanic who provided the estimate returns to complete the work.

The collection of funds is the major stumbling block and may take from several weeks to a month. During this period, water may be obtained from the older traditional sources, from irrigation channels, or by purchases from private wells or tanker trucks. Most villages do not have adequate reserves for major repairs, but several of those with organized water councils do. Local council contributions to major repairs vary considerably. Some provide no assistance. Others offer loans. In one local council visited, a fund of 5,000 YR was set aside for each village to draw upon for major repairs. Occasionally, all repairs are paid for by the local council, if the village is considered too poor to provide its own funds.

Engine replacement is a large financial burden for rural villages. Commonly used smaller engines in the 20hp range cost 50,000 YR; those in the 65hp range run upwards of 130,000 YR. These expenditures are clearly beyond the capacity of most villages. Diesel driven rural water systems have only been in widespread use for a little more than ten years, with many of the systems installed more recently than that. Several operators said they felt as if they had new engines since they had replaced all the internal parts. However, as replacement becomes necessary, it is likely that villagers will appeal to the local councils, which will most certainly be under pressure to assist. Even if the cost of a new engine is shared, these purchases will be a burden on local council budgets.

Summary

Poor operational practices and inadequately performed minor repairs contribute to major problems and the eventual need for system component replacement. Villagers believe their operational and minor repair performance is adequate but are less able to deal with more expensive repairs and replacement. However, the frequency of major repairs reported indicates that O&M practices are deficient. A program of operator training and awareness will improve system reliability and reduce expenses. The private sector is providing adequate service and should be encouraged to continue to do so. However, the local councils have an implicit responsibility to provide at least partial funding for major repair and replacement costs, particularly where they are now actively involved in water activities. It would be in their own interest to help villagers reduce these costs if only to minimize village requests for financial assistance. Their role should be in training operators in the proper use and care of equipment and ensuring that operators are better equipped to assess repair needs.

Chapter 4

LESSONS LEARNED

USAID and other donors have been contributing to water sector development in the Yemen Arab Republic for the past fifteen years and have learned a number of important lessons in the process.

At the village level, it is clear that people are willing to contribute to the installation of an improved supply system and look forward to having water piped to their houses through private connections. Financial and in-kind contributions are common, particularly for systems installed under CLCCD and local council auspices. This spirit of self-help continues from the period of civil unrest in the sixties when no assistance was forthcoming from the central government. Normal RWSD practice has been to provide rural water systems without villager contribution. The USAID 044 project pioneered the requirement for villager contribution which other donors, particularly the Dutch, are now incorporating into future rural water projects, convinced that a financial stake increases villagers' commitment to the long-term upkeep of the system.

The villagers' interest in improved systems is largely for convenience and not so much a search for better health. The health education component has been missing from most water projects. Discussions with CLCCD officials concerning the proposed PL480 program indicated less interest in health education than in the provision of water system hardware. Future projects should include a health education component to assure maximum health benefits from the provision of water.

Many households are willing to pay for private connections. RWSD provides a basic system and pipeline with the provision for private connections which households install at their own cost. In some villages, all households are served by private connections. In cases where household connections dominate, water meters are often in use, to ensure the equitable apportionment of water fees. This approach should be encouraged because it fosters a more careful accounting of funds and a greater awareness of the need for water conservation.

For the most part, villagers have taken the responsibility for operation and maintenance costs but do not have a sufficient understanding of what proper care of equipment really entails. Rarely is enough money collected to cover major repairs and almost never is component replacement factored into user fees. Although replacement is not yet a major problem, it will become a much more pressing issue as equipment gets older. In all likelihood, the local councils, the government and/or donors will then be called upon for assistance. It is imperative to make villagers aware of the long-term financial commitment required of them to operate and maintain their water systems.

Inoperative water systems can be traced to a number of technical and nontechnical causes. Operation, maintenance, and repair difficulties are only some of these. One major cause is community conflict, either from clashes of personality or a lack of understanding of the organizational and management

requirements of operating a water system. One fairly common source of conflict is the use of a water system by more than one village. While this arrangement is often tempting since the well, pump, and engine costs are high, the potential for conflict increases when two or more villages must agree on management of a water system and water allocation, particularly when these resources are limited. Since villagers are responsible for operating and maintaining their systems, additional care needs to be taken to ensure that villagers are organized and in agreement concerning these issues.

Another major cause of inoperative water systems is inadequate water sources, either because the water table is dropping and wells are going dry as a result of unrestricted drilling of wells and the depletion of aquifers, or because inadequate test pumping when the well was drilled did not establish that the water source would be insufficient for demand at the site. These are difficult issues in Yemen and there has been some attempt to address them. However, political and logistical considerations complicate agreement on solutions. Efforts should be intensified to ensure that water resources are adequate prior to construction of rural water systems, and more stringent well development and test pumping procedures and regulations for well drilling and water use should be enforced.

The private sector is very active in the Yemen Arab Republic. Much of the drilling and construction of new water supply systems is performed by private contractors and almost all repair services are provided by private mechanics, workshops, and importing agents. The strength of these arrangements is their flexibility in delivering services to rural villages, but the weakness is in monitoring the quality and completeness of these services. Villagers often cannot interpret the symptoms of impending trouble, nor assess the quality of the work eventually performed, and its likely cost. They are vulnerable to unscrupulous mechanics who could overcharge for unnecessary services. A part of any training program for upgrading operator skills should include a knowledge of basic troubleshooting and of cost ranges for ordinary repairs.

The USAID 044 project has had positive impacts which were not explicitly stated in the original project goals. The Dutch have adopted the village contribution model initiated for RWSD projects by the 044 project. It is now accepted by many that village contributions to the construction of a village water system improves the chances for long term success in system operation. A second impact is the widespread adoption of the 044 design for concrete elevated tanks. These tanks are now being built in many villages as part of local council efforts to upgrade service.

Chapter 5

RECOMMENDED STRATEGIES FOR IMPROVING O&M SERVICES

This chapter outlines several possible strategies for the improvement of operation and maintenance services for rural water systems, as directed by USAID/Yemen, within the context of a PL480 local currency program. A small amount of foreign currency is available from other sources for offshore purchase of tools and equipment, but no expatriate contractor is to be involved.

5.1 Primary Assumptions

One of the major strengths of the O&M infrastructure in Yemen is its flexibility in meeting the needs of rural villages. The ability to obtain repair services from any private sector mechanic or company allows villagers to act quickly and, excluding systems inoperative because of inadequate water sources and community conflict, has contributed to a fair level of reliability for rural water systems.

Control of these systems should remain at the village level. Villagers are directly affected by the inefficient functioning of their water systems and are much more likely to cut to the heart of a problem and ensure that the necessary repairs and servicing are carried out. The local councils provide financial backstopping in many subdistricts but should not take on the responsibility for operating or maintaining pumps and engines. The private sector is fulfilling this role far better than the local councils could.

Major repairs present problems to villages and local councils. Funds are often in short supply and repairs cannot be undertaken immediately, although spares and skilled mechanics are available. There are many complaints about the high cost of repairs arising in part from the villagers' ignorance of what needs to be done and the readiness of some mechanics to take advantage of this situation.

Villagers are able and willing to pay for moderate maintenance and repairs. When completed water systems are turned over to them, they must devise ways of collecting revenue to cover an operator's salary and the cost of fuel and oil. In some cases, the collected funds allow for a reserve for necessary repairs. But if they are not sufficient, additional levies must be assessed for this purpose. In one form or another this appears to be the almost universal practice.

The local councils have implicit responsibility for major repair and replacement costs of pumping equipment which are generally beyond the villages' financial capacity. These repairs are likely to include engine overhaul and engine or pump replacement.

The private sector is active and capable of providing O&M services in almost all rural areas but the cost can be very high, particularly for major repairs. This

is partly because of higher labor and field servicing charges by mechanics from urban areas, and because major repairs are likely to require more expensive parts. Mechanics capable of minor repairs are to be found in many rural villages and provide services at reasonable cost.

Any intervention by public sector institutions in the operation and maintenance of rural village pumping systems should take place under the direction of the CLCCD and the local council network. This structure is the only one with de facto and de jure responsibility for assisting villagers in meeting operation, maintenance, and repair needs. However, local councils at present fall short of meeting this obligation.

5.2 PL 480 Program Characteristics and the CLCCD

PL480 funds, in Yemeni rials, belong to the Government of the Yemen Arab Republic (YAR) and are generated by the sale of PL480 Title I food aid. They amount to a concessional loan to the YAR and by agreement are jointly programmed by the YAR and USAID. Proposals for use of the funds originate from the government entity expecting to receive them, and are forwarded to the Central Planning Organization (CPO) of the YAR for approval by that body and USAID/Yemen. CPO authorizes the release of funds direct to the requesting ministry or department once approval has been given. This process is intended to fund worthwhile projects as defined by CPO priorities, but USAID control over detailed project activities is somewhat limited.

The currently proposed PL480 project, designed to assist rural water supply systems through the local councils, will provide funding through the CLCCD office in Sana'a. The two components of the project are expected to be:

- low cost additions, such as handpumps, or modest improvements to existing installations
- a pilot activity for improving O&M for diesel driven pumping systems

The plan of action is still under discussion between USAID and CLCCD officials. USAID has indicated willingness to assist CLCCD with program planning. It appears that the CLCCD understands and supports the project component which will provide funds for low cost water projects. However, understanding of the O&M component seems limited.

CLCCD has recently established an O&M section in its project activities department staffed by a mechanical engineering school graduate and a technical school graduate. The apparent impetus for the formation of this section is a Japanese project in support of heavy equipment owned by the councils. This equipment consists of about 300 pieces including bulldozers, graders, and loaders (roughly half Caterpillar and half Komatsu). CLCCD is willing to listen to proposals to assist rural water system O&M, but the capabilities of the newly established section are limited, and the major priority appears to be for central workshop facilities to support heavy equipment.

There is significant interest at the Local council (LCCD) level in rural water supply systems and their ongoing problems of operation and maintenance. But the technical resources at this level are not very impressive. The CLCCD operates branch offices at the governorate level with technical sections that could be the locus of O&M activities in support of water projects. The alternatives of locating O&M services at the local council level or at the governorate level are discussed in Appendix C. In either case, the CLCCD must fully understand and agree to the location and scope of services to be provided.

5.3 Recommended Program Strategy

The services which an O&M support program could provide fall into three broad categories: operator training, repair evaluation, and repairs. In addition, a workshop could be a resource for a local council or branch office to provide the same services. Given the current approach to rural water system operation, the most appropriate role for a publicly supported O&M program is in training pump operators and providing them with a limited selection of tools to perform maintenance services. In discussions with USAID/Yemen officials, the initial scope of work's focus on O&M workshops as a vehicle for improving the reliability of rural water supplies was expanded to include a plan and facilities for training village pump operators. However, the details of workshop specifications, and tools and equipment lists, as originally requested can be found in the appendices.

It is clearly in the interests of both the villages and the local councils, which provide the ultimate safety net for water systems in their subdistricts to work to upgrade the skills of pump operators. Attempts to provide this training at central facilities have not met with full success because of the variety of equipment being used and the tendency to send unsuitable individuals for training. Rural training courses are more effective because the types of equipment in use tend to be similar, and pump operators are more likely to be able to attend a short local course than a longer course in Sana'a.

The findings reported in Chapter 3 suggest that operator training offers the best opportunity for improving rural water supply reliability. This training should focus on

- Operation and maintenance of engines and pumps
- Proper use of tools
- Attention to minor repair needs
- Assessing costs of major repairs

Training centers should be located at CLCCD branch offices and be capable of conducting short courses both at these sites and in larger towns within the governorate to allow operators from the surrounding areas to attend without undue difficulty. Training should begin in areas like the Tihana region where the local councils are already involved in repair activities.

5.4 Services to be Provided

In accordance with the findings of this report, USAID interest in working with the CLCCD and local councils, and the limitations inherent in a PL480 project, the recommended strategy for the improvement of rural water supplies is to assist in upgrading the skills of pump operators through training.

Poor pump operator skills contribute to a higher than average repair and water system component replacement rate. In the past, RWSD has provided courses for pump operators at a facility in Sana'a, first supported by WHO and later by USAID/Yemen through the 044 project. These courses were as effective as on-site training because of the candidate selection process, the wide variety of equipment in use, and the high cost of supporting candidates away from home. Later efforts have focused on training at the village level during system construction. However, this training does not address the needs of the many systems not installed by RWSD or installed during periods when the training courses were not available. The cost of on-site training is high but is more effective than centralized training. However, by establishing a workshop/training center at the CLCCD branch office level and focusing training at the subdistrict level by running courses for 10-15 area pump operators, a compromise between effectiveness and cost can be achieved.

The training courses should be provided as a CLCCD-subsidized service to local councils and pump operators. The costs associated with operators' attendance (such as travel and per diem) should not be paid from project funds. Hence, there is no need for detailed administrative and billing procedures as originally envisioned. Local councils active in the water pumping activities of their villages understand the benefit of operator training in reducing the future burden on local council financial resources. It is in the best interests of local councils to request a training course in their area, provide logistical support for it and arrange for pump operators to attend.

USAID should support the establishment of this pump operator training unit within the CLCCD structure at the branch office level. Initially only one training unit should be established to allow evaluation of its effectiveness before funds and effort are committed to a broader program at other CLCCD branch offices. PL480 funds should be used to

- Employ a mechanic/trainer
- Employ a training assistant
- Provide office and storage space for the unit
- Cover in-country transportation expenses by public conveyance, if necessary, but not by the purchase of a vehicle

The hard currency component should be used to purchase training aids and tool kits for operators who have completed the training course, as outlined in Appendices H, I, and J. The person chosen to conduct the training should be a mechanic with broad experience in the maintenance and repair of small diesel

engines and pumps. He should, as part of the program, accompany the Dutch supported mobile workshop on its tour of villages. The mechanic/trainer should also receive training in how to effectively conduct training of pump operators. It may be necessary to use part of the foreign exchange component to provide this training in a third country. Such courses are available in Egypt and Jordan. In addition, it may be possible to provide local training using the soon to be released WASH publication, Training Guide for Operation and Maintenance Supervisors of Rural Water Systems.

The training course should be no longer than four days and largely practical and should include the following topics:

- Basic theory of diesel engine and diesel generator operation
- Basic theory of pump operation (vertical turbine or electrical submersible as appropriate)
- Proper use of hand tools
- Common engine and pump problems, their symptoms, and appropriate solutions (This is not intended to teach operators to perform repairs but to help them identify problems and the sort of mechanic who should be summoned for assistance)
- Warnings about tasks which should not be attempted by the operator
- The importance of properly functioning water systems to the health of villagers and
- A listing of operator tasks to include how and how often to change oil and filters, repair taps and pipelines, etc.

A three-to-four-day curriculum should be developed by condensing the one month curriculum used by RWSD, and utilizing training manuals available from local pump and engine suppliers and training aids purchased with the foreign exchange component of the project. A local consultant should be employed to develop a detailed course outline. It may be necessary to request the assistance of a US based consultant such as WASH.

This program arrangement has several advantages:

- The cooperative councils assist in the training of pump operators but do not assume full responsibility for water systems
- The villages retain responsibility for O&M and for raising revenue to cover costs

- The private sector continues to provide major repair services, which it does effectively

- Training and tools are provided to improve O&M and minor repair standards and reduce major repair frequency and cost

5.5 Technical Assistance, Implementation, and Project Administration

Project administration will have to be agreed upon by USAID/Yemen, the CPO, and the CLCCD. At a later stage one or more CLCCD branch offices must be selected for the pilot program. Administrative procedures must be determined by USAID/Yemen, the CLCCD, participating local councils and the mechanic/trainer. The proposed tasks for each of the entities involved are described below.

Tasks for USAID/Yemen

- Participate in the selection of the site for the pilot training unit

- Review the selection process for the mechanic/trainer position

- Provide short term training for the mechanic/trainer within the region

- Arrange for local consultant support for curriculum development

- Procure, warehouse, and distribute the tools and training equipment purchased overseas

Tasks for the CLCCD (including branch offices)

- Select CLCCD branch office for pilot training unit

- Arrange office and workshop space for the training unit at selected CLCCD branch office (PL480 funds)

- Provide training unit staff salaries (with PL480 funds)

- Provide transportation and per diem for the trainer and his assistant for training unit courses held at local council towns

- Provide tool kits for pump operators who complete the training course (one per village only, which should formally belong to the local council)

Tasks for participating LCCD (local council)

- Request the training course for their local council area and nominate pump operator trainees.
- Cover part of the cost for pump trainees, depending on circumstances.
- Take responsibility for logistics, including space for the training course.
- Periodically inventory operator tool kits

Tasks for the Mechanic/Trainer

- Provide training to pump operators
- Provide trainees with a list of tasks for the operator and a list of suggested tasks for the villagers (see Appendix E).

5.6 Project Monitoring

The major part of this function should fall to the local council and the CLCCD branch office. The technical section at the CLCCD branch office and the CLCCD head office should keep track of the number of operators trained and the local councils in which training has taken place. At the end of one year, the CLCCD should commission a report to assess the effectiveness of the training and suggest improvements in the curriculum and/or the logistical arrangements.

Chapter 6

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The provision of potable water in rural areas involves the collaboration of donors, RWSD, the CLCCD, the MAF, the private sector and the villagers themselves. A number of donor projects have not required village contributions (in cash or in kind) for construction of a water project. However, several donors have required participation and all systems constructed under the auspices of the cooperative council system require contributions. Contributions are often in the range of 25-30 percent of the total cost. Villagers clearly consider water supply a worthwhile investment in public services.

Upon completion, villagers become fully responsible for all aspects of operation and maintenance of their water system. Central government agencies have no mandated role in O&M or rural water supply. In most cases villages are knowledgeable about how to keep their water systems operational. They do this by calling on the assistance of the private sector in the form of local mechanics or mechanics from importing agents when necessary. The strengths of this system are its flexibility and the retention of funds and decision making power at the village level.

It appears that between 25-35 percent of rural water systems out of order at any one time. The reasons fall into three major categories: community conflict; inadequate water sources; and operation, maintenance, and repair difficulties. The O&M related difficulties appear to account for roughly 10 percent of inoperative systems. The major difficulties in the O&M and repair appear to be lack of preventative maintenance, poor completion of minor repairs in many cases and the high cost of major repairs.

The private sector is active in the repair of rural water systems both through provision of spare parts and provision of repair services, even to remote villages. The first level of service is likely to be a local mechanic but villages do call experts from urban centers when they believe it is necessary. Repairs performed by such mechanics are likely to be expensive. Interviews with operators reveal that major repairs are likely to be necessary about once a year. The duration of system down time is likely to be three weeks or more as funds are collected and the necessary spares procured. During this period, villagers may get water from irrigation channels, traditional cistern sources or by purchasing from private well owners. Often, the local councils are called upon for financial assistance in completing repairs.

The local councils have the mandate to assist villagers in solving local problems, but not to take responsibility for resolving them. This assistance can take several forms. Most commonly it is financial assistance. There is considerable diversity in the quality and responsiveness of the over 200 local councils to villager's needs. Since local councils are composed of elected officials who should be concerned about constituent problems, the better local

councils are concerned and responsive, within the limits of their resources, to village needs. Many local councils do participate in the repair of village water systems by providing funds for system repairs; some even subsidize ongoing O&M. In these instances, the local councils have become implicitly responsible for the major costs of repair and replacement of components for village water supplies in their areas.

6.2 Recommendations

- USAID/Yemen should endorse a CLCCD program to support water system operation that does not get local councils involved in the direct provision of O&M services to rural villages but continues to leave villages responsible for the operation, maintenance and repair of their own water systems.

- The major activity recommended is the establishment of a pilot pump operator training unit at a selected CLCCD branch office to conduct training courses both at site and at local council locations within the governorate.

- These courses should be designed with a three-to-four-day curriculum and for groups of 6-10 trainees and be subsidized by the CLCCD as an investment in the long-term benefits of reduced repair and replacement of equipment.

- The training program should be established as part of USAID/Yemen's overall PL480 support to CLCCD. This includes the training units (including office and storage space), transportation (but not vehicle purchase), and per-diem related expenses.

- The available foreign exchange component should be used to purchase tool kits and training aids and provide possible short-term training for the unit staff.

- Future expansion of the activity should await an evaluation of the success of the pilot program.

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APPENDIX A

PERSONS INTERVIEWED

APPENDIX A

PERSONS INTERVIEWED

USAID/Yemen

Ken Sherper	Mission Director
Ben Hawley	Program Officer
Robert Mitchell	General Development Officer
Mohammed Abdul Kader	General Development Program Assistant
John Wiles	Health Development Officer
Soheir Sukkay-Stolba	Consultant
Fred Huxley	Consultant

LCCD

Abdulla Al Muda'ay	Director, Public Relations
Abdul Malek Salam	Deputy Director, Public Relations
Mohamed Atiah	Chief, Maintenance and Servicing Departmen
Hamood Al Salahi	Chief, Workshop Department
Abdulla Kassim Aldwari	Hydrogeologist, Workshop Department
Mohammed Saif Ali	Diesel Mechanic, Workshop Department
Hibat Allah Ali Shareem	General Secretary, Secretarial Branch Hodeidah
Alnehari Yahya	Chief, LCCD Affairs Section, Hodeidah
Ahamed Farah	Chief, Technical Section, Hodeidah

LCCD

Mohammed Abkar M.Adhan	Chairman, Bajil LCCD
Abdulla Hassan Hajam	Treasurer, Bajil LCCD
Abdulla Mohamed Digrah	Chairman, Al Duraihimi LCCD
Mohammed Abdulla	Secretary General, Hodeidah LCCD
Q. Abdulla Yehia AlWa'aly	Secretary General, Al Mansuriah LCCD
Mohamed Ahamed Gably	Treasurer, Al Mansuriah LCCD
Salim Za'aby	Treasurer, Al Marawa'a LCCD

Peace Corps

Russ Morrison	Associate Director
Bruce Paluk	Volunteer

Sana'a University

Abdulla Al Hizayzi	Technician, Field Research Station

RWSD

Ibrahim El Shami	Acting Director, RWSD
Abdulla Mohammed Al Amir	Chief, Mechanical Department
Abdulla A. Malik	Director of Drilling and Hydrology

Dutch Aid

Sjef Ijzerman	First Secretary Royal Dutch Embassy
Theo Haagsma	Project Leader, SRWSD
Dirk Smits	Team Leader, Technical Assistance Unit, Rada'a Integrated Rural Development Project
Helene Nyland	SNV Administration

UN and Affiliated Agencies

Anwar Hussain	Senior Program Officer
Asmael Al Halily	Assistant Project Officer
Julian Kosinski	Project Manager, WHO
Carl DeGroot	UN Volunteer

Japanese Aid

Takeshi Sakai	JICA expert
Hideaki Shimazaki	Drilling Contractor

Private Sector

Doug Craig	Consultant and ex-NTF
Paul Sleylati	Sales Manager, Adhban for Trade and Marketing Co.,Ltd
Abdul Rahim Mohammed	Manager, Nasser Workshop
Ali Naji Ahmed Mohammed	Proprietor, Workshop Badan
Abdulla Tabat Abdul Kader	Proprietor, Al Kanar Workshop
Aboud Zubedi	Service Manager, Al Watari
Ali Obad Jumaan	General Manager, Brothers International Co., Ltd.
Mohammed Nasser	Deputy General Manager, Jumaan Trading and Industrial Corporation
John Lucas de Sa	Commercial Manager, Tihama Tractor and Engineering, Ltd.
Yousef Mohsin Saleh	Technical Manager, Tihama Tractors and Engineering, Ltd.
A. Alyeman Abdulla Ishak	General Manager, Ibn Alyemen Trading

APPENDIX B

SCOPE OF WORK

Appendix B

SCOPE OF WORK

YEMEN: O&M SERVICE FACILITIES

BACKGROUND

Over the past year, USAID cooperated with the Confederation of Local Councils for Cooperative Development (CLCCD) to design a decentralized community development program that mobilizes local resources to meet locally identified needs.

The CLCCDs have different infrastructure and social service responsiblities, including the provision of potable water. USAID's proposed program with the councils will build their capabilities through (1) supporting an expanded program to help implement small appropriate technology water systems and (2) providing O&M services for these systems.

During FY 89, USAID and the CLCCD will develop a proposal to be submitted to the Central Planning Organization (CPO) for PL 480 local currency funds to support this program. Limited FX resources are available to plan and equip the workshops to offer O&M services. The present scope of services is to prepare a workplan to develop, extend, and implement these services, as well as to prepare a list of tools and equipment required to provide the O&M services.

WASH assisted USAID in the initial examination of this program. The examination focussed on the feasibility of introducing handpumps to rural areas. (See WASH Field Report No. 224, Feasibility of Handpump Installation and Manufacture in the Yemen Arab Republic.) USAID is cooperating with the Peace Corps and the CLCCDs in testing an Indian Mark II pump in the Tihama. However, it is clear that handpumps represent only one type of appropriate technology. The proposed PL 480 program will extend to other low-cost simple power-driven pumps. The costs of the water systems will be kept to a minimum, as will USAID's contributions through YARG-owned PL 400 local currency proceeds. By limiting the costs of the systems, the technologies will be kept fairly simple; USAID's contributions will also be limited. These cost, technology, and USAID restrictions will help make this a self-targeted program. Smaller and poorer villages are the most likely beneficiaries. However, there will be larger settlements near these villages that will have more capital and energy-intensive water technologies. The proposed O&M program must be able to service these systems, as well as the smaller ones.

USAID commissioned a survey of 102 water systems installed under Project 279-0044; another 20 non-USAID projects were also studied. Although the reliability and validity of the survey data can be questioned, it is clear from this study and others (e.g., M.A. Mullick, Socio-Economic Aspects of Rural Water Supply and Sanitation) that USAID has been supporting fairly capital and energy-intensive water systems. In some areas (e.g., Dhamar governorate, an area receiving considerable Arab and other donor assistance to help villages recover from a serious earthquake in 1982), villagers make little or no contribution to the systems provided them. More generally, beneficiary villages have neither the financial resources nor technical capabilities to repair their systems once they develop technical problems.

A large majority of the systems are non-operable for indefinite periods of the year.

Means must be found to provide reliable and affordable O&M services.

The local councils would like to strengthen their ability to provide these services. They would like, at a minimum, at least one O&M center in each governorate. At present, there are (ill-equipped) centers in the country's three largest cities only: Sana'a, Taiz, and Hodeidah. An earlier mobile service center in Hajja no longer is in operation.

Approximately 20 percent of Yemen's population has access to potable water. Only a small minority of the country's 60,000 villages have these benefits. Still, a numerically large and growing number of villages do have power pumps. These systems were provided through the initiative and resources of the villages themselves, as well as through systems sponsored in part by different donors in cooperation with the local councils, the Rural Water Supply Department, and various ministries. The RWSD and the local councils have their own drilling equipment, but it is believed that the private sector is responsible for implementing most water systems and providing rudimentary O&M services.

The present scope of services requires, to the maximum extent possible, that private sector capabilities be included in the development of an O&M system to be under the auspices of the CLCCD.

This new system will focus initially on the seven governorates served by the Mission's two health projects. They are Hajja, Sadda, Marib, and Hodeidah, where the projects currently operate, as well as Mahweit, al Jawf, and el Bayda, three governorates to be served shortly by USAID's Child Survival project. It is intended that village health education programs will be linked to water systems in these governorates.

In addition to PL 480 resources to be devoted to water programs in these governorates, approximately $150,000 remaining in Project 0044 are available to procure tools and equipment for the new O&M services. These funds can also be used to help train and initiate these new services. The funds must be disbursed by September 30, 1989, the PACD for this project.

The WASH expert, in cooperation with the Mission and the local councils, must prepare a procurement plan to assure that this deadline is met.

USAID has eight other activities in support of this decentralization program. First, Pragma Corporation (through Dr. Soheir Sokkary Stolba) is developing a family-welfare village-outreach program in the Taiz governorate. This program will draw on women's association in adapting a/v materials to be used in villages. Second, Dr. Stolba and another anthropologist will conduct intensive health and social impact studies in a small number of villages in order to identify the lessons of experience on how to assure that local water projects are successfully implemented, that O&M services are successfully provided, that women benefit from these projects and that beneficial health effects are realized. This study will be initiated in mid-January, 1989. Third, PD&S funds have been requested

to study how best to mobilize village resources to meet local infrastructure and service needs. Fourth, an amendment to the Mission's Development Training III Project (279-0080) is being prepared. It will provide in-country and other training opportunities for those responsible for local development (general purpose government) activities. Fifth, this same amendment will provide funds in support of local women's associations. Sixth, the local councils will receive used heavy equipment, vehicles, hospital beds, and other commodities contributed by the DOD under its excess commodity program. Seventh and especially important for the present program, the Mission's new TSFS project is providing a modest amount of FX for the design of a proposed PL 480 program. And eighth, USAID is cooperating with the Peace Corps in the earlier mentioned handpump experiment.

All of these activities are managed by USAID's General Development Office.

SCOPE OF SERVICES

In the context of the above developments and plans, WASH shall be responsible for the following seven tasks:

TASK 1: Prepare a specific strategy and implementation plan to establish a workshop for O&M services in support of rural water projects in cooperation with and under the supervision of the CLCCD and involving, to the maximum extent possible, the private sector.

TASK 2: Prepare a list of tools and equipment required by the CLCCD's proposed O&M service centers. The list shall include prices and sources of the commodities.

TASK 3: Prepare other specifications for the O&M workshops, including the space they will require.

TASK 4: Prepare a staff pattern and staff-training program for the centers.

TASK 5: Prepare administrative and billing procedures for handling the services to be provided by the centers.

TASK 6: Prepare a proposal for USAID's technical assistance to and management of the O&M services component of the proposed follow-on PL 480 program. USAID will assign one FSN engineer to this work.

TASK 7: Provide other recommendations to USAID and the CLCCD for the development, implementation, and management of this O&M workshop.

LEVEL OF EFFORT

It is anticipated that this assignment will require four person weeks of effort. A six day work week is authorized.

TIMING

The work shall start no later than the second week in January, 1989.

RESPONSIBILITIES

This activity is within the General Development Office. It will assign one FSN engineer to assist the consultant in this work. The CLCCD will cooperate in making arrangements for the consultant and advising him on the development of the O&M program.

REPORTS

The consultant will provide verbal reports, as requested, to the Mission. The consultant must prepare a draft final report to the Mission prior to departure from Yemen. A final report must be submitted to USAID within 30 days after mission comments on draft report.

QUALIFICATIONS

The consultant must have a minimum of five years prior relevant practical hands-on experience in the establishment and operation of O&M workshops; he/she must be thoroughly familiar with the tools and equipment of these workshops, and have experience in ordering the commodities and in training staff members in their use.

APPENDIX C

PROPOSED WORKSHOP LOCATIONS

APPENDIX C

PROPOSED WORKSHOP LOCATIONS

LCCD Based Services

The sub-district (or Nahiya) based local council (LCCD) is made up of members who are elected based on one representative member for every 500 residents. An administrative board of from 7-12 people is elected by the district representatives. The chairmen, general secretary and the treasurer are salaried and the remainder are volunteer. Local council budgets range from less than 200,000 YR to 45 million YR depending on the economic base within the council area and the number of residents. The local councils appear to have considerable autonomy in how these budgets will be spent. However, larger project activities must be approved through the system described in Chapter 2. However, funds are available for hiring contract staff or providing funds for smaller activities. Sums of up to 25,000 YR can be spent without approval from either the CLCCD head offices or the Governorate branch offices. This means that some local councils already have an "engineer" on contract and have vehicles available. Note that some local councils do not have any operating vehicles.

The location of training workshops capable of providing operator training at the local council level has a number of distinct advantages and several drawbacks. The advantages include:

- The number of water systems at the local council level simplifies the task of training and follow-up.
- The smaller local council geographical areas reduces travel times.
- The location of the project at this level will help ensure that it is most responsive to villagers needs.
- Location in an appropriate local council can assist in providing training and service advice where the private sector is less active.
- Evaluation and monitoring the effects of provision of operator training services is enhanced by limiting the geographical scope of the activity.

However, there are disadvantages to an local council project locus. These include:

- The visibility of the activity is more limited so that other local councils may not be aware of the pilot project.

- The activity must single out one or at most a few local councils while the national need is great.

- Transportation for the activity may be difficult if the local council has limited means of transportation.

- The salary of a qualified technician to provide operator training is likely to exceed the salary of local council officials,

- There may be difficulty in employing a qualified trainer willing to work exclusively in the smaller towns characteristic of local council centers.

- Monitoring activity progress through the council bureaucracy may be difficult.

- If training of pumpers is to be the prime focus, the number of systems may be too few and the trainer/technician may be able to cover all district needs without being fully employed.

Governorate Based Services

The CLCCD branch office of the local council network is the intermediary step in the council system between the CLCCD and the local council. The head of the CLCCD branch office is an elected official answerable to the local councils in his Governorate and to the CLCCD main offices in Sana'a. Most of the CLCCD branch office staff are permanent employees of the CLCCD. The coordination and planning of many local council project activities lies with the CLCCD branch office. All Governorate CLCCD branch offices include a projects department. These departments usually include technically trained staff, although typically not to University level. The activities of these departments are largely in the area of project design for water projects, schools, health facilities and roads. At this time these offices have no capacity to perform O&M services for water systems, vehicles or heavy equipment.

The budget for CLCCD branch office salaries, overhead and Governorate level activities is provided from central government funds and does not come directly from the revenue collected for development activities (the "Zakat" tax and special taxes described in Chapter 2). The services of the technical department are available to the local councils.

The location of a training unit and workshop capable of providing training at the Governorate level has a number of distinct advantages and several drawbacks. The advantages include:

The services could be made available to a larger number of villages.

- The activity would be more visible to local councils who could model local council level activities after it according to their means.

- Administration of the project would be easier as the offices at the governorate level are branch offices of the CLCCD

In addition there are a series of potential disadvantages. These include:

- A more dispersed activity will not be as effective a demonstration as a concentrated one

- There will be greater demands placed on a service technician and he will be less able to respond as needed to local requests.

- The mechanic/trainer will be required to spend considerable time away from home, travelling and providing training in more rural areas.

- The CLCCD branch offices are likely to be caught between the competing priorities of the CLCCD and the needs of the local councils.

APPENDIX D

PROJECT STAFFING SCENARIOS FOR A MAINTENANCE WORKSHOP

APPENDIX D

PROJECT STAFFING SCENARIOS FOR A MAINTENANCE WORKSHOP

If an O&M workshop is to be provided as outlined in the original scope of work, care must be taken that this does not lead to a centralization of O&M and repair services. Experiences in other countries indicates that this approach is likely to result in less responsive maintenance and repair services, particularly if the service is not adequately funded. The current approach to O&M practices in YAR should be encouraged as the use of the private sector for O&M and repair services provides flexibility in obtaining these services. In addition, when villagers remain responsible for O&M, they can make the decisions necessary to meet their needs as they see fit.

If O&M workshops are to be built, each workshop unit will require a qualified mechanic able to provide training to pump operators. Each will also require a mechanic's helper or assistant. In addition, a storekeeper/clerk should be available. The duties of the storekeeper/clerk is not likely to occupy a full time position.

Contracting for services on an as needed basis or limited term contract basis is widely accepted and practiced at all levels of the local council system. At the local council level only the chairman, the general secretary and the treasurer are salaried employees. All other employees are hired on contract basis. At the CLCCD main office and Governorate branch office level, a core staff are permanent employees and others are hired on a contract basis. The advantages and disadvantages of contracting are:

- Direct control by contracting agency
- limited contract term does not burden contracting agency if the arrangement is not satisfactory.
- limited involvement of the private sector if the workshop is pressured to perform repairs

A second possibility is to co-finance the building and equipping of a workshop and lease the space and equipment in exchange for the provision of training services. The terms of the lease to a qualified mechanic would require the replacement or repair of lost or damaged tools and the training of a specified number of pump operators. The advantages of this approach are:

- The local council would derive income from the lease of the workshop.
- The sub-district would have a resource in the form of an equipped workshop

- The local councils would be in a position to co-finance the training of pump operators without a subsidy from their development budgets.

- The lessee/mechanic would be free to utilize the workshop as he saw fit (after satisfying the terms of his contract). This could include the repair of water systems for a fee.

- The private sector would continue to play the pivotal role in the repair of water systems.

- The start-up capital required for the establishment of a workshop is moderate making it possible to replicate the pilot if it proves successful.

- Vehicle requirements could be left to the lessee/mechanic, reducing the initial capital investment.

The potential disadvantages include:

- There may not be a local mechanic/trainer who is fully qualified to provide these services.

- The contract may be awarded to someone not capable of providing the training to area operators.

- It may be difficult to monitor the quality of the training provided.

These potential problems cannot be totally mitigated. However, since at least the PL480 funding must pass through the CLCCD and the equipment is to be supplied with donor hard currency funds, oversight by the CLCCD and the donor should be established early in implementation phase. An oversight board made up of local council officials, CLCCD branch office official (preferably from the technical and accounting departments), and a donor representative. This board should approve the selection of the mechanic and monitor the pilot program for at least one year.

Monitoring operator training will require that the mechanic/trainer submit several checklists and forms (signed by the operator and/or the village representative) to the local council. These forms would include a village water system inventory form, a training checklist, a list of tools left for the pump operator, a list of village tests to be completed, and a list of operator tasks. Details of these forms are included in later appendices.

APPENDIX E

OPERATOR TRAINING OUTLINE

Appendix E

Operator Training Outline

Operator training activities to be performed by the mechanic/trainer fall into two major areas. These are defined below along with the details of the subtasks to be included.

Operator training checklist

The original checklist form (signed by operator) should go to LCCD, copies to operator and the CLCCD branch office.

The Operator training curriculum should include:

Basic theory of diesel operation and how it differs from gasoline engines

Proper use of tools (operator to sign an inventory form upon reciept of tools, original to LCCD)

Importance of proper O&M and the effects it has on breakdowns and repair costs

How to determine the proper intervals for oil changes and filter replacement

Common engine and pump problems, their symptoms and appropriate solutions (example attached in appendix K)

Warnings about tasks which should not be attempted by the operator

The importance of a properly functioning water system to the health of villagers

Operator duties

A copy of the list of operator duties should be kept by the operator and a village representative.

Daily duties

Check oil level
Clean engine and environs
Check for fuel or oil leaks repair as necessary)
Check pipeline and taps for leaks and repair as necessary
Start and stop engine

Periodic duties

Change engine oil (frequency to be determined by usage)
Renew or replace filters (usage determines frequency)
Tighten engine mounting bolts
Grease or oil pumphead (as appropriate)
Check drive belt tension (adjust or replace as appropriate)
Clean storage tank

In addition, each operator should, with the assistance of others as necessary, develop an inventory of water systems components. This inventory will help to ensure that the right spareas are procured when this becomes necessary. The mechanic/trainor should provide guidance on how to perform this inventory. The operator, the village local council representative and the local council should have a copy of this inventory. The inventory should include:

Engine and pump

- Engine rating/make/model (include boosters if applicable)
- Pump make /model (include boosters if appropriate)
- No, length and dia. of pipes in the well
- Generator rating/make/model (if appropriate)
- Electrical control make and model (if appropriate)
- Configuration: (including boosters if applicable)
  - Belt drive vertical turbine
  - Shaft drive vertical turbine
  - Generator driven submersible pump
  - Other (specify)
- Estimate of the hours per day operating
- Estimate of daily fuel consumption

Tank and distribution system

- Elevated tank (Y/N)
- Height to tank inlet
- Tank volume
- Pipeline diameter well to tank
- Horizontal distance well to tank
- Vertical distance well to tank inlet
- Number of private connections
- Number of public tap locations

In addition the mechanic/trainer should provide guidance to the operator about improvements that the village should be made to the water supply system to hels assure that the system operates properly and that system provides the maximum health benefit. Examples of such improvements include:

- Build pumphouse/shade engine
- Create a proper soakaway for engine cooling water
- Create proper soakaways around public taps
- Provide support for elevated pipe runs
- Bury piplines under roads
- Fill and grade where standing water sits

APPENDIX F

SELECTION CRITERIA

APPENDIX F

SELECTION CRITERIA

Participant Governorate branch offices and LCCDs:

Participating CLCCD branch offices in the pump operator training activity should be initially limited to one until the details of the activity are clear and the first pilot training unit is in operation. Additional Training unit sites should then be considered. The participating Governorate should be selected to ensure that the pilot program have the greatest chance of success in order to provide a model for future activities, the following selection criteria are recommended.

- The local councils within the jurisdiction of the CLCCD branch office should have an established commitment to supporting district villages in meeting their water needs.
- CLCCD management must have strong leadership and the desire and ability to equitably respond to requests from local councils in their region.
- The water systems in the region should as much as possible be uniform in configuration, and not include electric submersible pumps.

Mechanic/entrepreneur

It should be recognized from the outset that the perfect mechanic is unlikely to be available for this position. The fully qualified mechanics with training ability are all likely to be employed in major urban areas and will not wish to relocate. The following criteria should be employed in the selection process.

- The mechanic/trainer must be literate and should have some formal training in pump and engine operation and maintenance.
- The mechanic/trainer should have broad experience with the engines and pumps found in the district. If there is any question, less emphasis should be placed on formal training or certification.
- The mechanic/trainer should be clearly aware of the training responsibilities and that repair of water systems is outside his responsibility.
- The mechanic/trainer should be prepared to travel for a month to six weeks to receive training in what to include in and how to conduct the operator training program (to be arranged with the Dutch supported RIRDP)

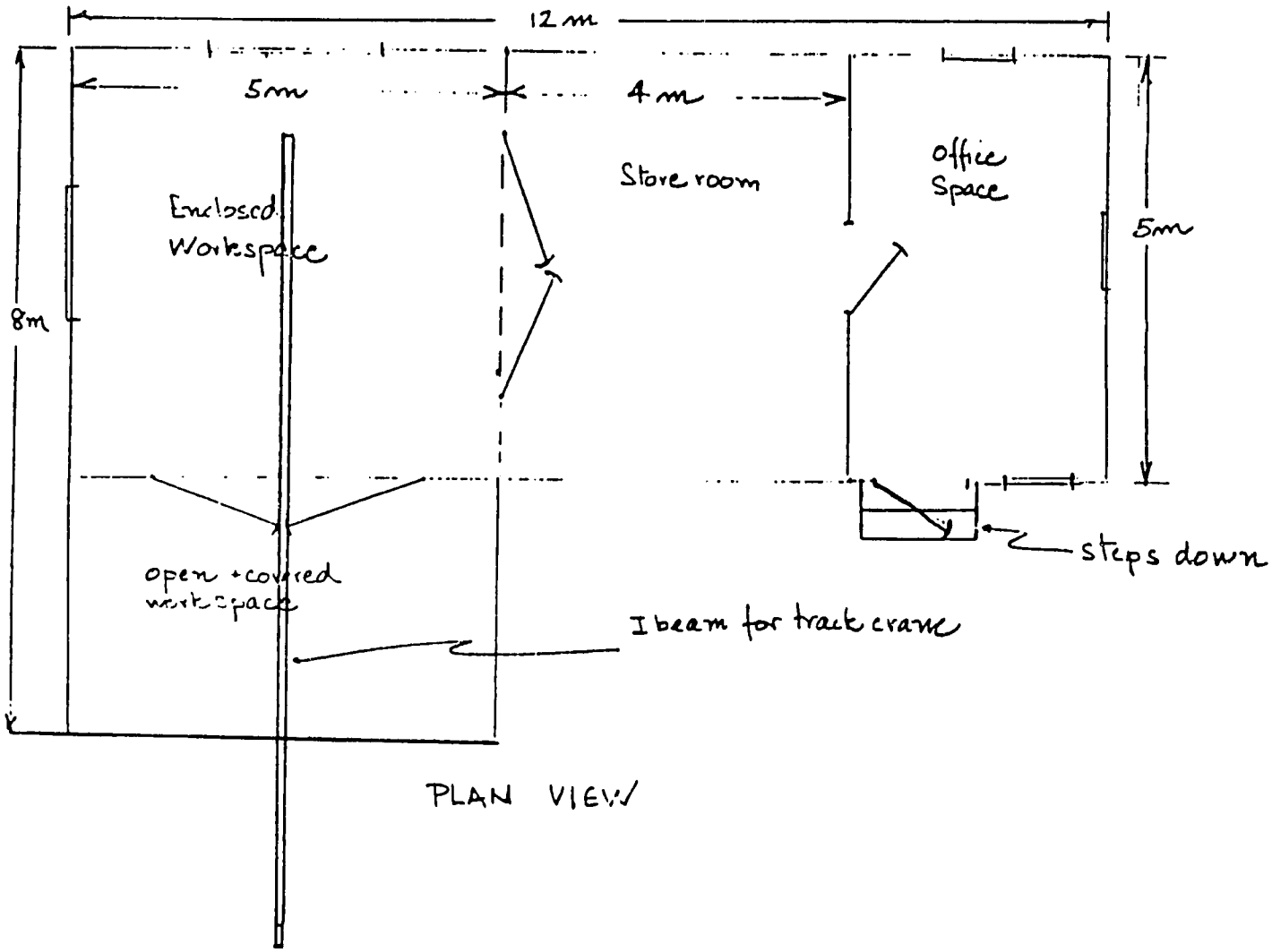
The mechanic/trainer should understand the considerable travel requirements inherent in conducting training in more rural areas

APPENDIX G

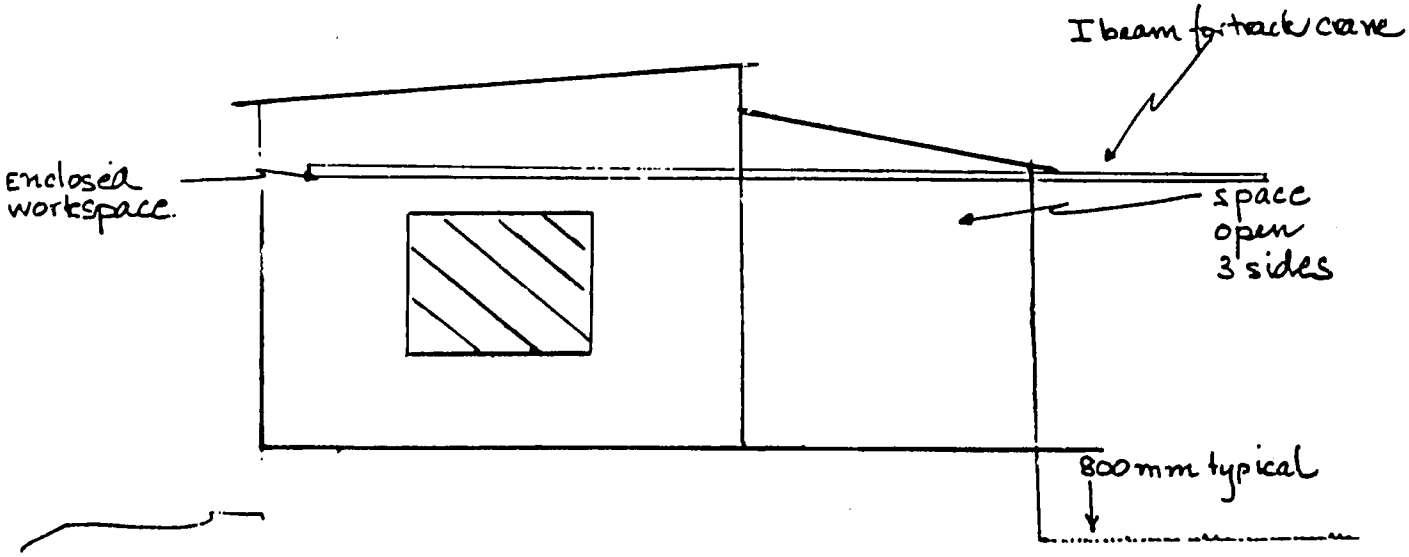
PROPOSED WORKSHOP LAYOUT

APPENDIX G

PROPOSED WORKSHOP LAYOUT



PLAN VIEW



ELEVATION VIEW

1/2" = 1 meter

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APPENDIX H

SUGGESTED OPERATOR TOOL KIT

Appendix H

Suggested operator tool kit

Tool kits to be supplied to pump operators upon completion of operator training course.

	Ref1
2 blade electician's pocket knife (spear/screwdriver)	1655
Sandard pattern hacksaw	1683
1 doz. Std. carbon hacksaw blades	1683
10" mill file (bastard cut)	1687
8" round file (bastard cut)	1687
14 " pipeline welders half round file	1687
Metric pocket hex key set (1.5-6 mm)	1779
10 pcs slotted/phillips screwdriver set (prem. grade)	1784
5 pcs maintenance pliers set	1803
Vice grips - 7" curved jaw w/o cutters	1815
Heavy duty pipe wrenches (24" straight) - set of 2	1813
8" adjustable wrench (premium grade)	1812
12 oz ball peen hammer	1871
Steel tool box (24x9x10 or suffient for tool kit)	1898
Corrosion resistant brass lock for tool box	836

(1) Ref. indicates where item found in McMaster-Carr Catalog 94, equivalent items acceptable

Estimated weight	60 lbs
Estimated cost	US$ 300

Tool kit should also include include the following locally purchased items

1/2 kilo rag cloth
whisk broom
10 liter metal bucket
scrub brush
8" utility funnel
wire brush
shovel

APPENDIX I

WORKSHOP TOOLS

APPENDIX I

Workshop Tools

The following hand tools are required for the workshop and for field and workshop servicing of small water supply systems.

	Ref[1]
100 pcs 1/4,3/8,1/2 drive metric socket and tool set	1835
Torque wrench 10-150 dual inch/metric 1/2"adj. rachet	1856
8 pcs metric 3/8 drive manual impact driver	1852
Vice grips 7" std jaw w/o wire cutters	1815
Vice grips 10" curved jaw w/o wire cutters	1815
5 pcs all purpose pliers set	1803
Internal/external retaining ring tools	1811
Tin snips 12" solid steel straight pattern	1644
Tin snips 10" solid steel curved pattern	1644
1 pcs ureathane dead blow hammer	1869
1lb ball peen hammer - premium grade wood handle	1871
2lb ball peen hammer - premium grade wood handle	1871
12lb wood handled blacksmith's sledge-carbon steel head	1872
4lb drilling hammer - wood handled	1872
16 oz fiberglass handled nail hammer straight claw	1874
1/2 doz 10" mill file smooth cut	1687
1/2 doz 12" mill file bastard cut	1687
1/2 doz 8" round file 2nd cut	1687
File handles for above	1691
File cleaner	1691
2 - 14" pipeline welders half round file	1687
2 - Standard pattern hacksaw	1683
2 doz std. carbon steel blades for hacksaw	1683
300 mm metric steel rule	1440
Diamond tipped scriber	1429
20 pcs mechanics punch and chisel set	1627
Metric try square	1441
5 pcs ezy-out screw extractor set	1516
30m/100 ft 3/8"wide steel tape rule	1436
18" std chrome adjustable wrench (normal opening)	1812
12" std chrome adjustable wrench (normal opening)	1812
8" std chrome adjustable wrench (normal opening)	1812
Set of 2 24" heavy duty pipe wrenches	1813
36" heavy duty pipe wrench	1813
Crowbar-gooseneck claw and wrecking bar 36'HD	1860
3 sheave pulley block wood shell bronze bushed	460
2 sheave pulley block wood shell bronze bushed	460
600 ft 3/4" manilla rope (for above blocks)	541
Pipe cutter (1/2" to 3")	1491
Pipe threaders 1-2" (1,1.25,1.5,2") rachet set (SD84-6 Reed Mfg.Co.)	
Pipe threader 2.5"-3" (85-10 Reed Mfg,Co.)	
Wheel puller - combination 2-3 jaw w reversible gears	1324

Metric tap, die and drill set	1498
Tap cutting fluid	572
Grease gun Heavy duty 16oz	576
Starrett No 216 Micrometer .010MM resolution (with case)	1451
Starrett No120 dial calipers 150mm range	1447
Feeler/thickness gages 13 leaf metric	1460
RPM gauge hand held analog (Model 1600-4 Jones Instument Co.)	
Voltage tester AC/DC type Can Std Approved	1423
Economy hand drill	1560
General Purpose Jobbers drill set 13 pcs metric	1519
10 pcs long arm metric hex key set	1778
Cutting pattern coal pick	1909
2 Shovels round point open back long handle	1906
Precision cast aluminum level 30"inch/metric ruled edge	1471
Cylinder hone set	1888
Ridge reamer	1888
Swivel grip oil filter wrench	1891
General purpose pump oiler st.9"spout, 16oz cap.	589
Master Mechanic's 12 drawer chest	1894
Master Mechanic's 9 drawer roller cabinet	1894
Mechanics hip roof steel tool box (2 each)	1899
Pilfer resistant tool chest 6.7 cu.ft.	1897

(1) Ref. indicates where item found in McMaster-Carr Catalog 94 (unless otherwise noted), equivalent item acceptable

Estimated weight	1000 lbs
Estimated cost	US$ 5,000

APPENDIX J

WORKSHOP EQUIPMENT

APPENDIX J

Workshop Equipment:

The following equipment is required for the repair of small engines at the workshop (not including re-boring and re-surfacing)

	Ref[1]
Diesel Generator 4 to 6Kw 220V/50Hz Single phase Air cooled engine prefered, Manufacturer must have an agent in YAR	
Portable Welder - Medium duty 4-6 Kw, 150-200 Amp Diesel driven prefered but petrol acceptable Manufacturer must have an agent in YAR	
Welding helmet Lt.wt.plastic, Fixed plate,#10 shade	651
Welding rods (mild steel)	
150-200 psi Compressor (horiz. tank mount 220V single phase)	1195
Manual chain hoist and trolley (2000 lb cap)	472
Lifting sling (6' 2" type 44)	542
Hydraulic jack (Sampson 5 ton)	428
Bench Grinder (220V 1phase 6" wheel)	1705
Electric drill (220 Volt 1/2" heavy duty VSR) (McMaster-Carr #95 pp1601)	
10 ton hydraulic jack press	1479
Double rachet puller	470
Combo bolt and wire rope cutter	1641
Steel top workbench (72"x36")	189
Laminated maple top workbench (72x30)	161
Multi purpose mechanic's bench vice	1765
Chain vice w/ tripod and stand	1764
Economy yoke pipe vice (1/8"-2" pipe)	1764
Double rachet puller	470
Small engine overhaul tool kit	1889
Safety glasses (cool view)	648
Injection nozzle tester (No.4200 Owatonna Tool Co)	
Adapter kit (No.4201 Owatonna Tool Co)	

Estimated weight	Lbs 2,500
Estimated cost	US$ 9,000

(1) Ref. indicates where item found in McMaster-Carr Catalog 94,
equivalent item acceptable

Additional office and storage equipment

Desk-double pedestal 30"x60"
Desk chair
File cabinet (4 drawer, legal size)
Steel 24" cabinet (2 in no)
Open steel shelves 36''x18' (3 in no.)

Estimated weight Lbs 300

Estimated cost US$ 1,000

Locally procured equipment and consumables

Push broom
10 liter bucket
Tripod (shear legs) for pulling riser pipe
1/2 kilo rag cloth
whisk broom
scrub brush
8" utility funnel
wire brush

TRAINING AIDS:

In order to facilitate the training of pump operators, items should be selected as appropriate from the listing if available training aids.

Note: Most training aids for diesel engines and pumps focus on the training of mechanics to service and repair equipment, not on basic owner/operator O&M procedures and their importance. In addition, no slide programs and video aids available in the US use Arabic as the working language.

1) Broadhead-Garrett, Mansfield, Ohio (800-321-6730)

4 cylinder, 4stroke diesel engine cut-away with transmission. Operated by 110V AC electric motor. It is an automobile diesel like a Volkswagon. Could be helpful but at $6120 is a bit expensive

Sectional model of a single cylinder diesel. About 18"high on a 10"by 10" base. This could be useful at $535 but it is made in Europe.

Diesel Engine Principles Transparency set. Set of 50 with 29 overlays. Covers basics to quite specific (and unnecessary) pieces on GMC unit injector, crown type and rotary distributing cam metering. About 10 of the transparencies are relevant. All in English. Full set is

$257

2) Intertec Publishing Co., Overland Kansas (913-541-6679)

Small diesel service manual. Covers service and repair of about 10 small diesels including Kubota, Lister and several others used in YAR. In English and not focused on O&M, but on repairs.

3)National Innovative Media (800-962-6662)

Complete diesel maintenance package for Apple computes (not Mac). 18 disc in 6 modules covering program covering engine repair, cooling systems intake/exhaust etc. Geared for US secondary and post secondary training. English and Truck diesel focus for $700

4)Kubota US, Compton CA. (213-537-2531)

Videos on diesel engine maintenance and diagnostic troubleshooting. Quite generic so it covers tractor line and marine lines as well. Videos are $35 and in English.

5)Techcom, Indianapolis, IN (317-359-4000)

Make cut-aways of just about anything. Estimate $2000 not including the engine initial cost for a small dsl. Estimate 750 for a vert. turbine pump.

6) Ken Cook Education Systems Butler WI, (800-362-2665)

$28,000 personalized video and computer training utilizing small diesel (Onan) engine. 15 or 20 program diesel technician + 10 programs on dsl/gen sets. Tools and equipment included. Mostly repair and overhaul and in English.

7) John Deere, Moline, IL (309-765-2967)

A Fundamentals of Service (FOS) series with text ($15) and slide set ($145). Also a Fundamentals of Machinery Maintenance series. Geared toward dealers and service agents and larger engines (tractors and heavy equipment). JD uses Yanmar for small diesel requirements and some aspects of these series may be helpful. Available in some Foreign languages but apparently not Arabic. Some videos also available.

APPENDIX K

ENGINE FAULT DIAGNOSIS

Appendix K

ENGINE FAULT DIAGNOSIS

FAULT	PROBABLE CAUSE	RECTIFICATION
Engine Difficult to Turn (Decompressed)	Lubricating oil too heavy	Drain sump and refill with correct oil
	Incorrect decompressor clearance	Re adjust
	Load not disconnected from the engine	Investigate
Engine Difficult to Start	Lack of fuel	Fill tank and bleed system
	Air in fuel system	Check and tighten all connections and bleed system
	Defective fuel pump	Overhaul or replace
	Faulty injector	Test or replace
	Low compression	See "Low Compression"
	Stopping control incorrectly positioned	Set in correct starting position
	Air cleaner or exhaust blocked	Clean
Failure to Obtain Normal Speed	Engine started under overload	Reduce load on engine until normal speed obtained
	Fuel system not primed	Bleed and prime
	Injection retarded	Retime fuel pump
Loss of Power	Incorrect fuel	Drain and refill tank with correct fuel
	Choked air cleaner	Change element
	Choked fuel filter	Change
	Fuel injector not fuctioning properly	Test injector, replace if necessary
	Fuel pump not operating correctly	Replace
	Incorrect tappet clearance	Adjust
	Choked exhaust	Remove restriction
Erratic or Uneven Running	Air in fuel system	Check all fuel lines and connectors, bleed system
	Incorrect fuel pump timing	Retime
	Faulty injector	Test and/or replace

FAULT	PROBABLE CAUSE	RECTIFICATION
Knocking	Incorrect timing	Retime fuel pump.
	Air in fuel system.	Check connections and bleed system.
	Incorrect fuel.	Change.
	Worn bearings.	Replace.
	Insufficient clearance between piston and cylinder head.	Adjust.
	Flywheel loose	Tighten.
	Excessive carbon deposit on piston	Remove Carbon.
	Engine loose on its mountings.	Tighten.
	Valve sticking in guide.	Clean stems and guides.
	Slack bearing	Fit new bearing if crankshaft is not worn.
Low Compression	Injector loose on its seat.	Check clamp is secure.
	Piston rings worn or broken.	Fit new rings.
	Leaking inlet or exhaust valves.	Regrind valve and seat.
	Cylinder head gasket leaking.	Check head is correctly torque loaded, replace gasket if necessary.
Low Oil Pressure	Insufficient oil.	Maintain correct oil level.
	Oil seals leaking.	Check and change defective seal.
	Worn bearings.	Change.
	Fractured pipe.	Change.
	Oil pump defective.	Change.
	Oil diluted.	Drain and refill with correct oil.
	Strainer choked.	Remove and clean.
	Relief valve not seating.	Renew if worn out.
	Oil pump plunger and valves worn or dirty.	Clean and renew as necessary.
Smoky Exhaust (BLACK)	Engine running on overload.	Check stopping control setting.
	Air cleaner choked.	Renew element.
	Injector nozzle dirty.	Clean or replace.
	Incorrect fuel.	Drain and refill with correct fuel.

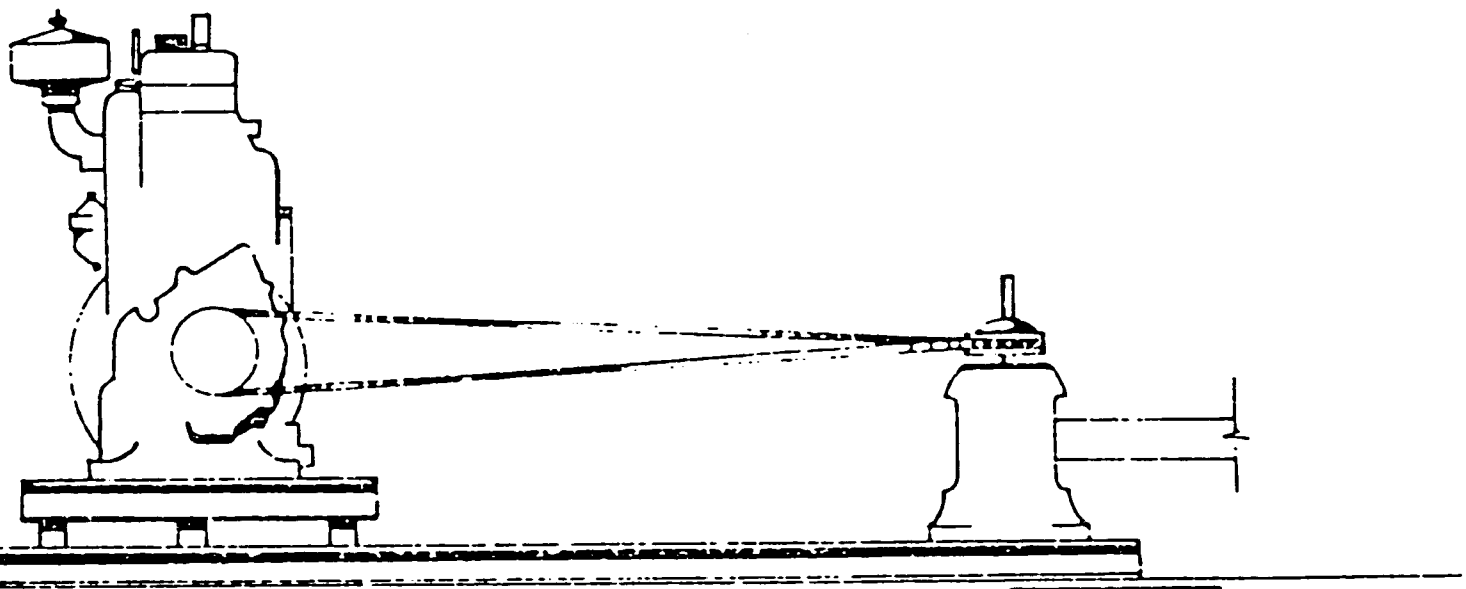
FAULT	PROBABLE CAUSE	RECTIFICATION
Smoky Exhaust (BLUE)	Piston rings worn. Cylinder bore worn.	Renew. Rebore and fit oversize rings.
Engine Stops	Insufficient fuel Loss of Compression Dirt in injector or fuel system Air in fuel system Water in fuel system	Fill tank and bleed system See "Low Compression" Investigate and clear Bleed system Drain, flush, fill with correct fuel and bleed system
High Oil Consumption	Valve Guides worn	Change guides or fit new cylinder head
Engine Overheating ST Engines	Cooling air recirculating Air cleaner or exhaust choked Injection retarded Insufficient lubricating oil Engine overloaded	Check that cooling air inlet and outlet are not obstructed Clean Retime fuel pump Check level Reduce load
Engine Overheating STW Engines	Thermostat faulty Injection timing faulty Jabsco pump faulty Blockage in water cooling system	Replace Check and adjust Change impellor or replace pump Check and renew all hoses and remove cylinder block inspection doors Clean out water channels in block and cylinder head
Excessive Carbon Deposits	Choked air filter. Choked exhaust system. Unsuitable fuel oil. Unsuitable lubricating oil. Continuous idling. Defective injector spraying Late injection of fuel	Clean. Dismantle and clean. Drain system, fill with correct fuel and bleed. Drain sump and refill with correct grade of oil. Increase engine load or stop engine. Check nozzle. Clean or replace. Check timing

OPERATION AND MAINTENANCE GUIDE

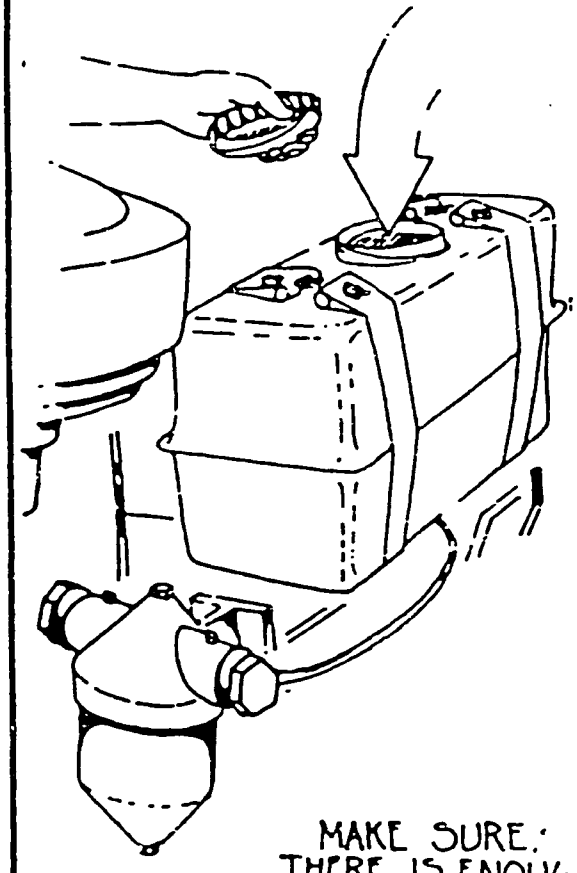
Lister Air-Cooled Example

Source: John Rockold
Former Peace Corps Volunteer, Botswana

BASIC ROUTINE MAINTENANCE OUT LINE FOR BOREHOLES EQUIPPED WITH THE AIR COOLED LISTER ENGINE. NATIONAL PUMP POWERHEAD AND MONO TYPE POWERHEAD.

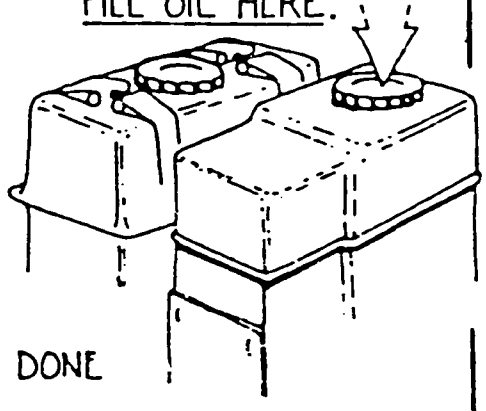


THESE JOBS SHOULD BE DONE EVERY DAY.



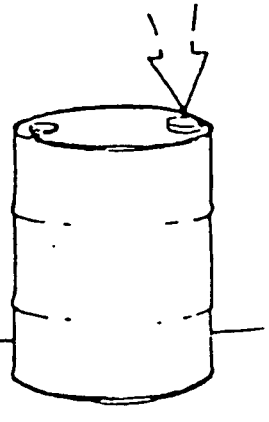
CHECK THE OIL EVERYDAY. IF THE OIL IS LOW, FILL TO THE RIGHT LEVEL. IF THE ENGINE LOSES TOO MUCH OIL DAILY NOTIFY DISTRICT COUNCL OR SUPERVISOR.

FILL OIL HERE.



(THESE JOBS ARE TO BE DONE WITH THE ENGINE OFF.)

MAKE SURE: THERE IS ENOUGH FUEL IN THE ENGINES FUEL TANK. THE FUEL TANK SHOULD BE FILLED EVERY DAY AFTER THE ENGINE IS SHUT OFF FOR THE LAST TIME THAT DAY. NEVER LET FUEL TANK RUN DRY.

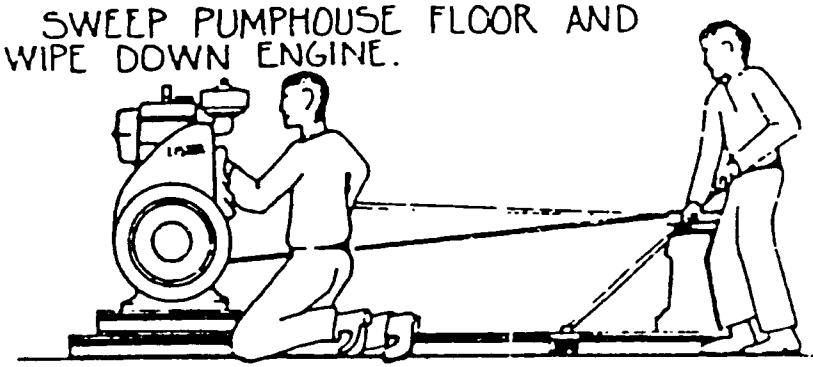


BE SURE TO USE CLEAN CONTAINERS.

USE HEAVY DUTY OIL SAE 20/20 W.

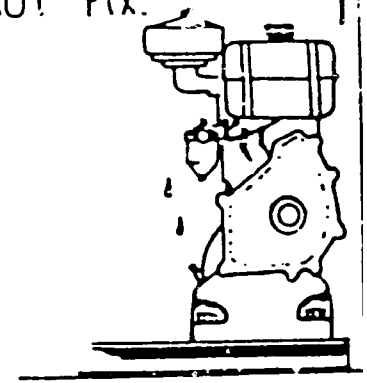
THESE JOBS SHOULD BE DONE EVERY DAY.

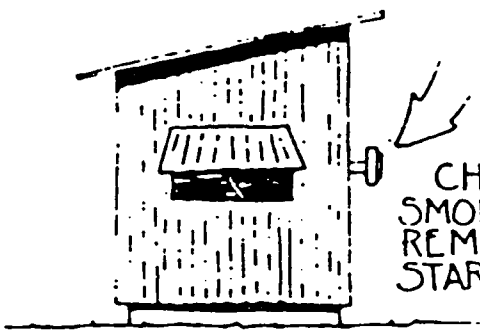
SWEEP PUMPHOUSE FLOOR AND WIPE DOWN ENGINE.



(THESE JOBS ARE TO BE DONE WITH THE ENGINE OFF.)

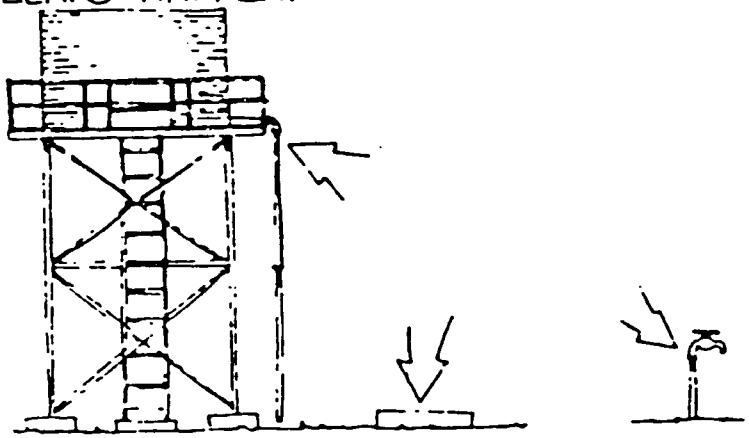
CHECK FOR LEAKS OF FUEL AND OIL. IF FUEL LEAKS HAPPEN. TIGHTEN THE FUEL FILTER HOOK UPS.
NOTIFY DISTRICT COUNCIL IF LEAKS HAPPEN THAT YOU CANNOT FIX.



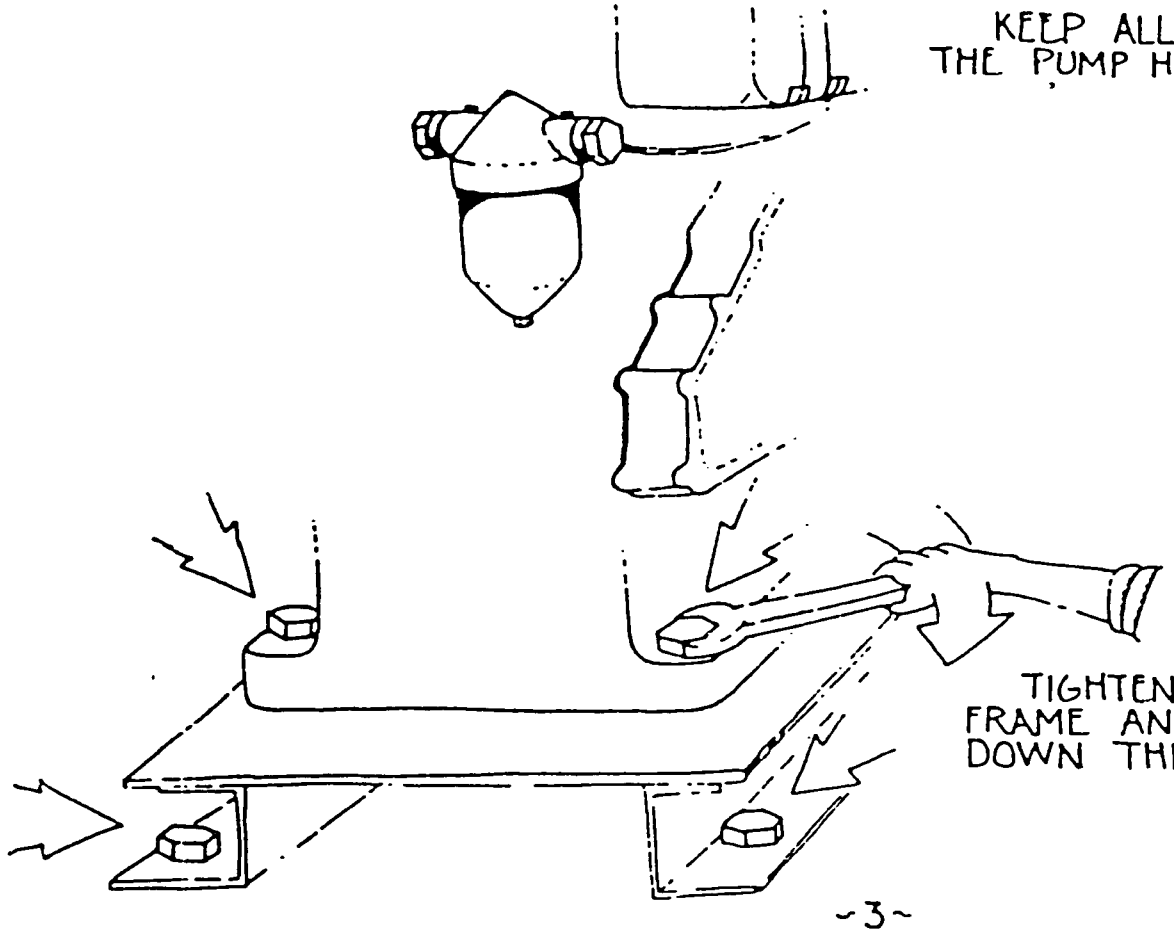


CHECK EXHAUST SMOKE. IF EXHAUST REMAINS DARK AFTER STARTING NOTIFY DISTRICT COUNCIL OR SUPERVISOR.

CHECK FOR LEAKS IN STANDPIPES. GATEVALES AND RESERVIOR. NOTIFY DISTRICT COUNCIL OR SUPERVISOR IF LEAKS HAPPEN.



THIS JOB SHOULD BE
DONE EVERY TWO WEEKS.

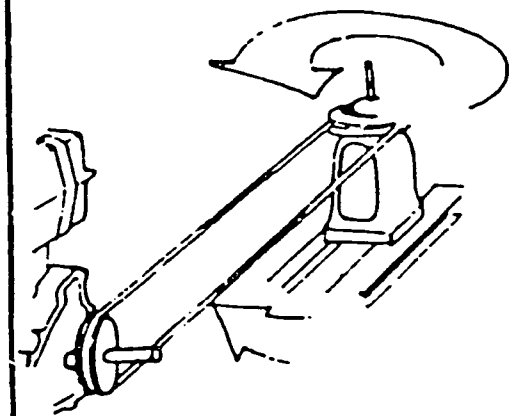


KEEP ALL TOOLS LOCKED INSIDE THE PUMP HOUSE WHEN NOT IN USE.

TIGHTEN ALL NUTS ON THE FRAME AND THE NUTS HOLDING DOWN THE ENGINE.

THESE JOBS SHOULD BE DONE EVERY MONTH.

CHECK DRIVING BELT. MAKE SURE DRIVING BELT IS NOT WORN AND HAS THE PROPER TENSION. MAKE SURE DRIVING BELT IS IN PROPER ALIGNMENT.



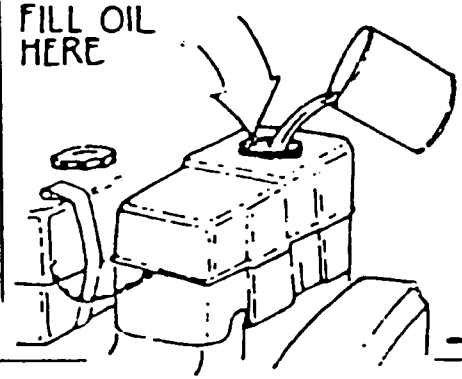
NOTIFY COUNCIL OR SUPERVISOR IF DRIVING BELT NEEDS ADJUSTMENT.

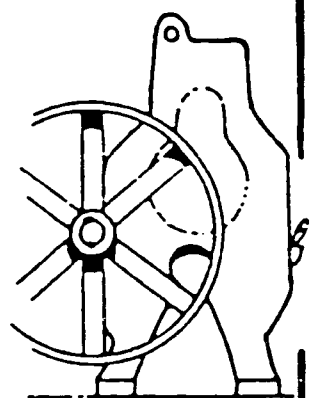
(THESE JOBS ARE TO BE DONE WITH THE ENGINE OFF.)

DRAIN THE OIL. REFILL THE OIL TO THE PROPER LEVEL.

USE HEAVY DUTY OIL SAE 20/20 W.

FILL OIL HERE

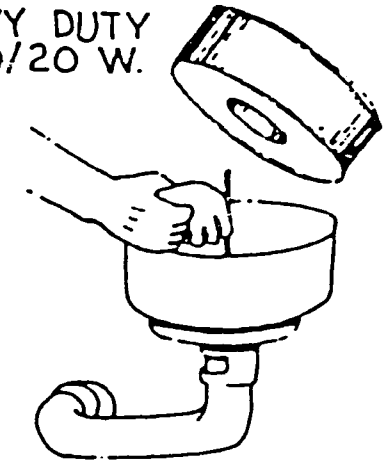




OIL PARTS ON POWER-HEAD. MAKE SURE THERE IS ENOUGH OIL INSIDE POWER-HEAD.

THESE JOBS SHOULD BE DONE EVERY TWO MONTHS.

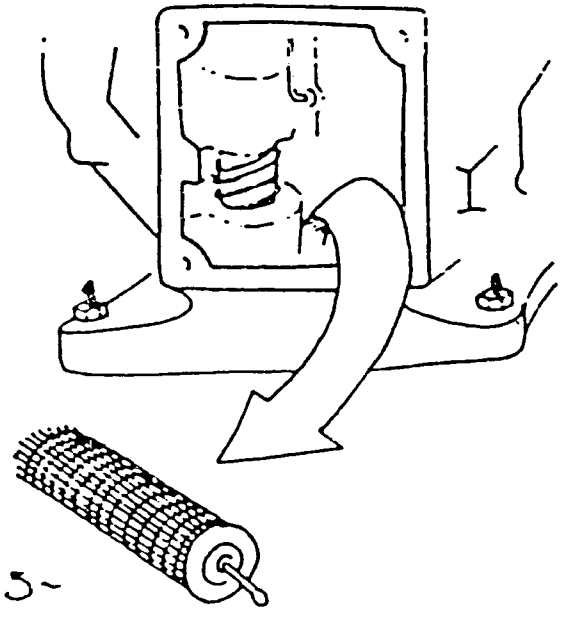
USE HEAVY DUTY OIL SAE 20/20 W.



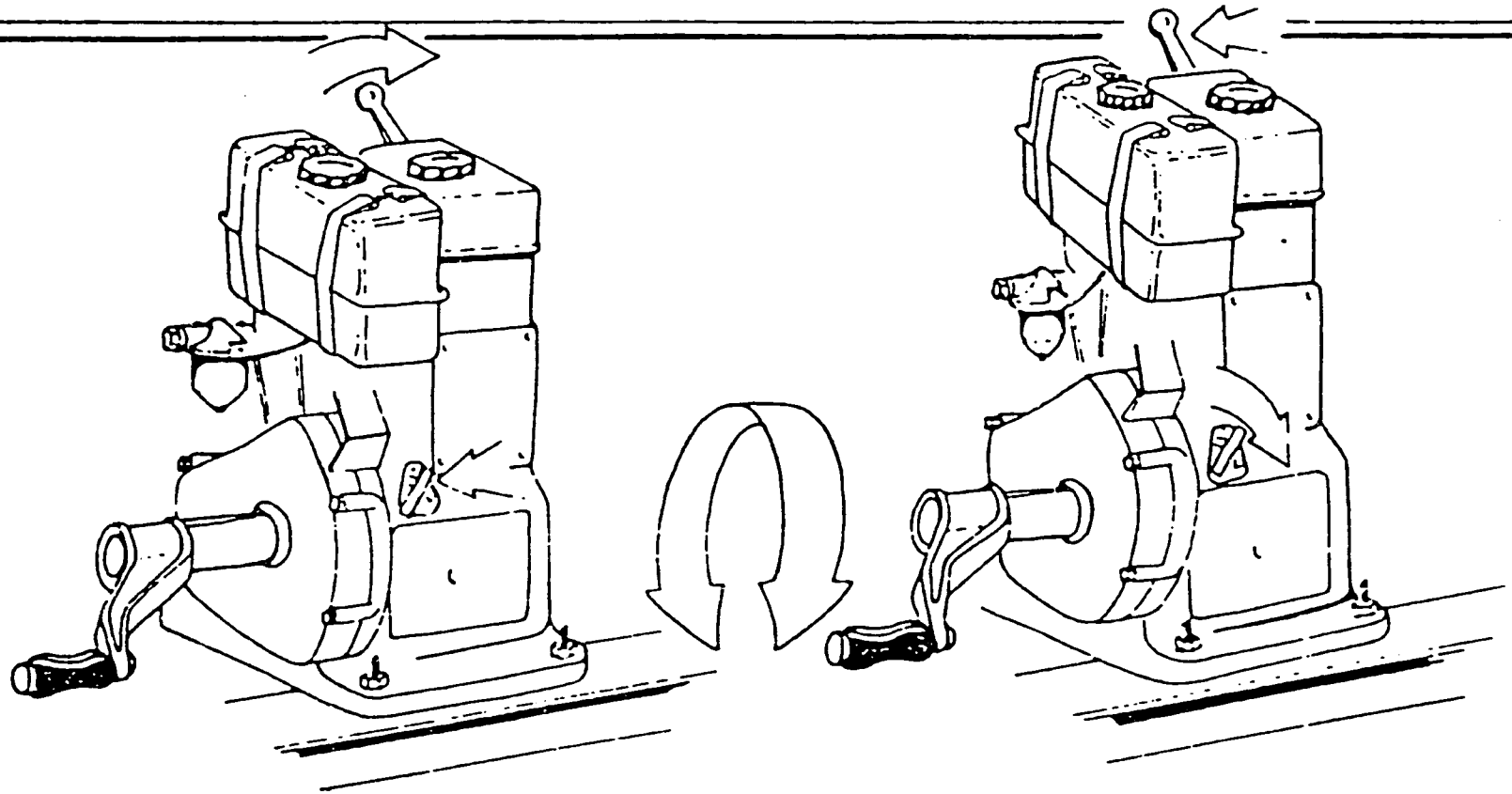
CLEAN OUT OLD OIL IN THE OIL BATH AIR FILTER. CLEAN AIR FILTER WITH FUEL. REFILL THE AIR FILTER PAN WITH NEW OIL.

(THESE JOBS ARE TO BE DONE WITH THE ENGINE OFF.)

TAKE OUT OIL STRAINER AND CLEAN WITH FUEL. PUT OIL STRAINER BACK IN.

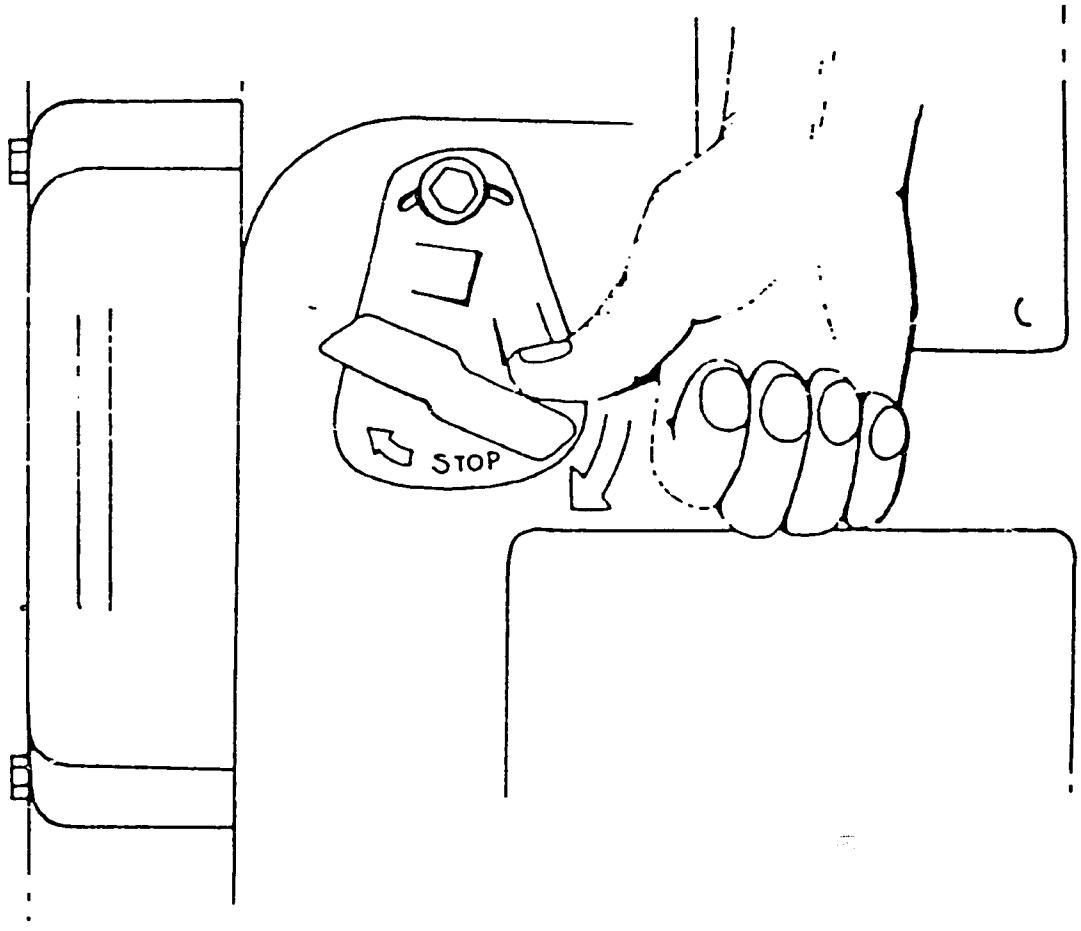


STARTING THE ENGINE (MAKE SURE DAILY JOBS ON THE ENGINE ARE COMPLETE BEFORE STARTING

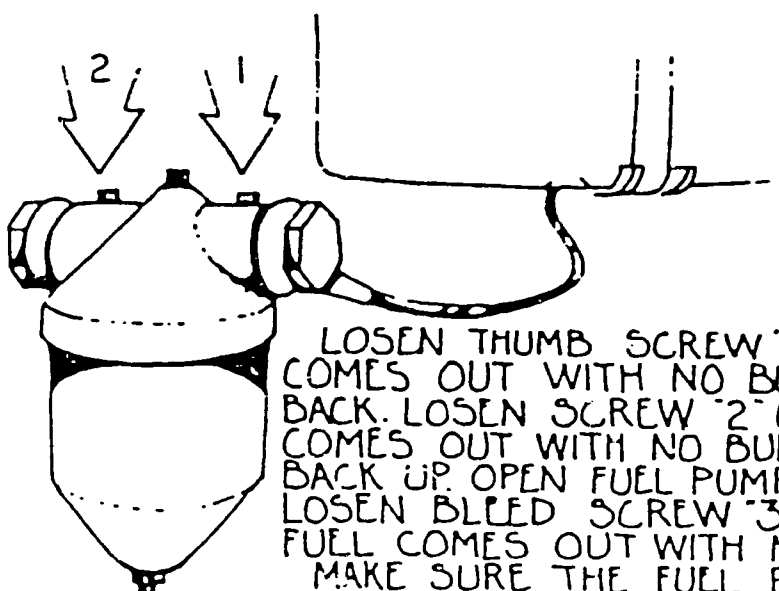


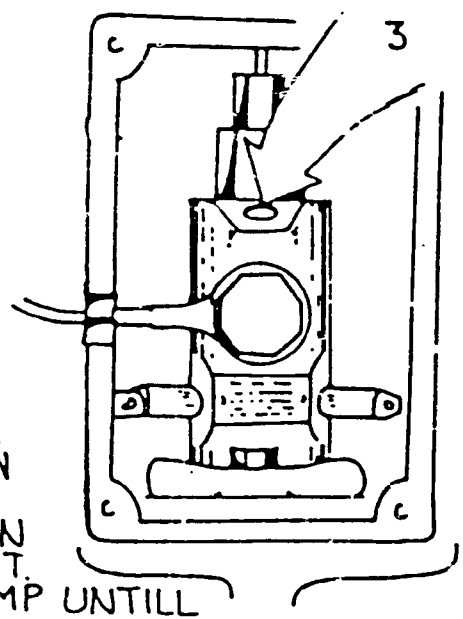
MOVE DECOMPRESSOR LEVER OVER TOWARDS THE FLYWHEEL. PUT THE FUEL CONTROL LEVER INTO THE START POSITION. OIL THE CRANKING SHAFT TURN THE CRANKING SHAFT WITH CRANK THREE TIMES. TURN THE CRANK TO THE STARTING SPEED AND PUSH THE DECOMPRESSOR LEVER AWAY FROM FLYWHEEL. ENGINE SHOULD START. WHEN ENGINE IS AT THE RIGHT SPEED PUT CONTROL LEVER INTO RUN POSITION.

TO STOP ENGINE PUSH CONTROL LEVER DOWN TO STOP POSITION. WAIT FOR ENGINE TO STOP TURNING THEN LET GO.



HOW TO BLEED THE FUEL LINE
(IF BY ACCIDENT FUEL TANK RUNS DRY FILL TANK AND THEN BLEED FUEL LINE. REMEMBER: NEVER LET FUEL TANK RUN DRY.)





LOSEN THUMB SCREW '1' UNTILL FUEL COMES OUT WITH NO BUBBLES. TIGHTEN BACK. LOSEN SCREW '2' UNTILL FUEL COMES OUT WITH NO BUBBLES. TIGHTEN BACK UP. OPEN FUEL PUMP COMPARTMENT. LOSEN BLEED SCREW '3' ON FUEL PUMP UNTILL FUEL COMES OUT WITH NO BUBBLES.

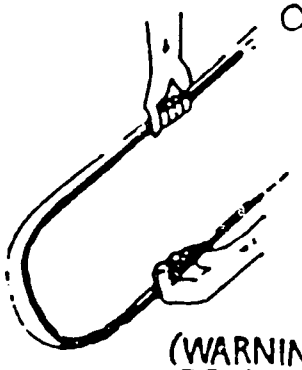
MAKE SURE THE FUEL PUMP BLEED SCREW IS TIGHTLY SCREWED BACK IN AFTER BLEEDING IS COMPLETED.

(WARNING: THIS SHOULD ONLY BE DONE IF TRAINNING HAS BEEN PROVIDED, OR BY A BOREHOLE MECHANIC.)

REPLACEMENT OF DRIVING BELTS(SAME SIZE .NO ADJUSTMENT) "ST" TO "MONO" TYPE

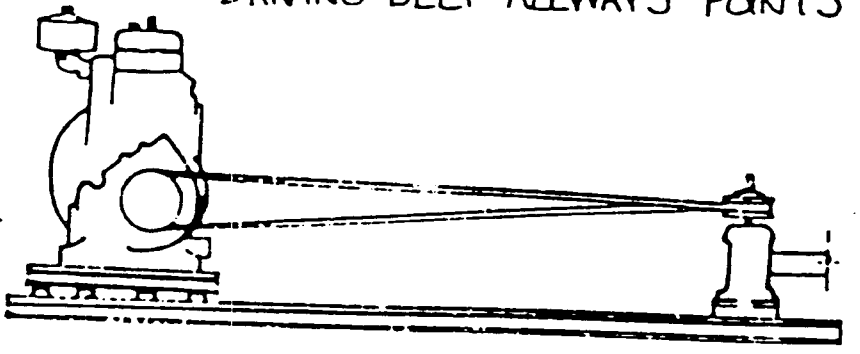
MAKE SURE ENGINE DECOMPRESSIOR IS ENGAGED.

PLACE DRIVING BELT "V" SIDE INWARDS ON THE ENGINE'S PULLEY.



(WARNING: THIS SHOULD ONLY BE DONE IF TRAINNING HAS BEEN PROVIDED OR BY BORE-HOLE MECHANIC.)

STRETCH DRIVING BELT TO POWER-HEAD. PULL THE DRIVING BELT OVER THE POWERHEAD TURNING CLOCK-WISE. MAKE SURE "V" SIDE OF DRIVING BELT ALLWAYS POINTS IN.



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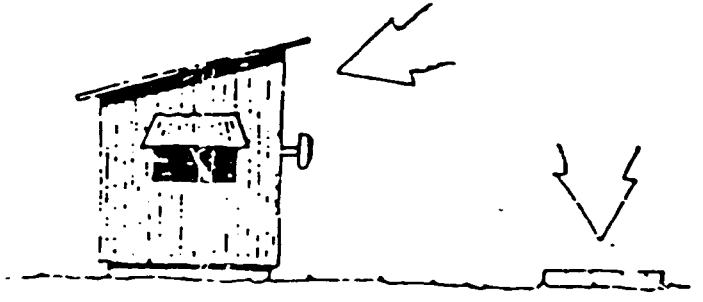
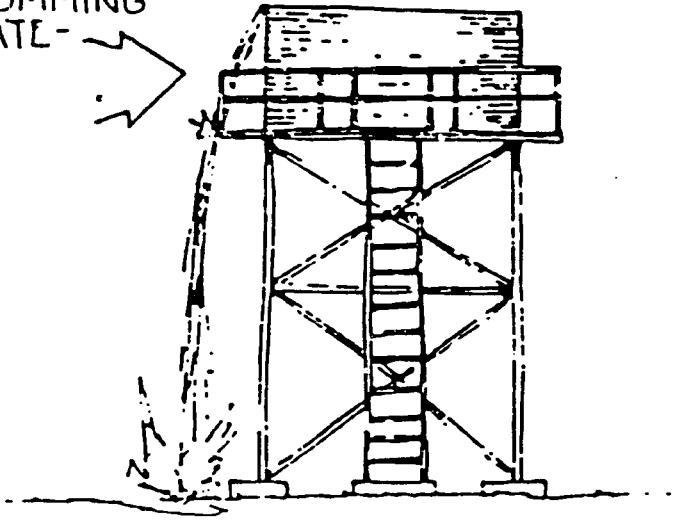
DO NOT RUN BOREHOLE WHEN WATER IS COMMING FROM THE TOP OF THE RESERVIOR OR WHEN GATE-VALVES ARE NOT OPEN.

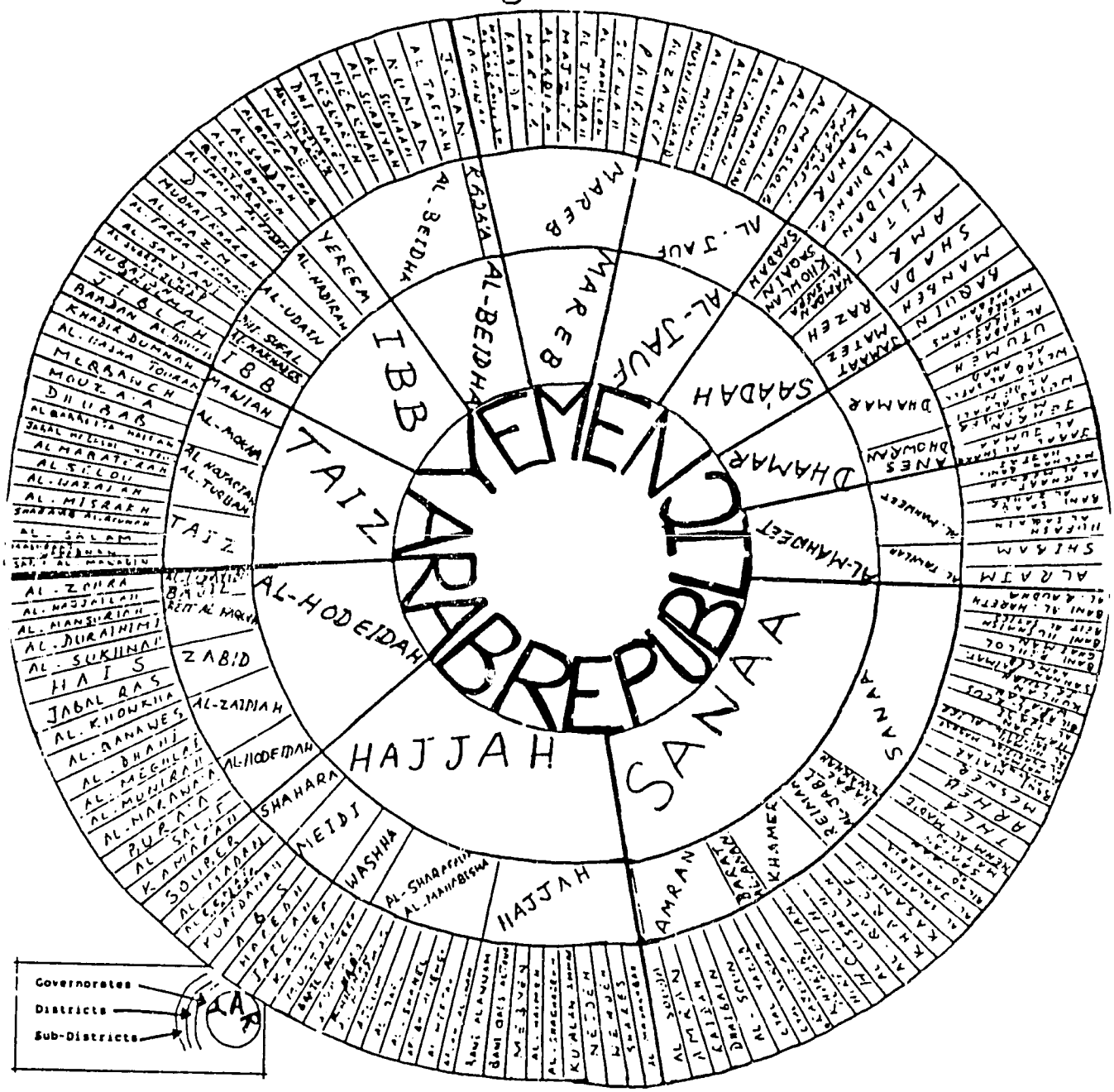




APPENDIX L

TABLES AND FIGURES

Fig 1



ADMINISTRATIVE DIVISIONS OF THE Y.A.R

Note: CLCCD branch offices exist at the Governorate level.

LCCD or local council offices exist at the district and sub-district level.

There is no council entity between the CLCCD branch office and the local council.

Table 1

Summary of Total CLCCD Projects in 1986

Governorate Branch		Roads No.	Roads Costs (YR)	Education No.	Education Costs (YR)	Health No.	Health Costs (YR)	Misc. No.	Misc. Costs (YR)	Total * Costs(YR)
Sana'a	*	60	2,465,030	97	19,446,850	3	183,335	41	11,381,399	40,669,189
		243	4,702,211	89	2,069,472	10	101,092	25	988,131	9,219,290
Taiz		68	7,235,821	123	12,879,013	23	2,066,282	49	6,838,141	47,447,649
		100	3,456,167	55	2,555,916	4	48,718	32	3,122,541	9,223,792
Hodeidah		12	1,482,847	34	8,868,274	3	585,825	33	11,359,505	42,919,762
		3	93,046	11	1,004,555	-	-	10	115,462	1,344,513
Ibb		28	2,788,587	95	8,502,264	4	320,974	37	4,013,080	19,722,552
		149	3,681,091	43	2,322,951	5	260,500	27	611,013	7,984,202
Dhamar		39	4,186,564	17	1,864,077	-	-	3	2,185,322	10,352,800
		53	1,324,497	3	2,957	1	15,852	6	208,713	1,552,019
Hajja		53	2,931,829	55	19,549,660	8	836,500	31	923,068	29,964,168
		123	4,141,874	42	2,227,245	6	428,743	15	250,910	7,557,682
Sa'ada		31	4,612,688	15	1,894,060	1	46,130	5	157,287	6,764,651
		47	2,887,719	46	1,511,715	3	17,451	1	40,000	4,490,635
Beidha		14	415,910	11	706,720	2	543,151	17	793,346	3,998,169
		25	480,799	30	497,792	1	30,000	24	719,020	2,410,709
Mahweet		18	1,430,596	31	1,430,795	5	200,886	11	856,480	4,062,157
		31	1,673,184	6	111,500	-	-	1	50,000	1,834,684
Marib		3	99,000	4	417,100	-	-	-	952,350	952,350
		3	9,000	7	15,080	-	-	-	-	24,080
Jawf		-	-	-	52,897	-	-	2	62,000	114,897
		-	-	1	30,000	20	7,000	-	-	37,000
Total		326	27,648,872	497	85,502,293	62	6,475,525	261	45,029,998	224,811,739
		777	22,449,588	333	12,349,183	31	959,356	141	6,105,790	45,678,606
GRAND TOTAL		1101	49,098,460	830	97,851,476	93	7,434,881	402	51,135,788	270,490,345

(Source: CLCCD, September, 1987.
* Note that for each governorate, the first figure is for new projects and the second for maintenance or rehabilitation. Grand totals include funding at capitol city level. Totals for governorates include water project costs listed in Table 1.)

Table 2

Summary of CLCCD Water Projects in 1986

Governorate Branch	New Projects		Project Maintenance/ Rehabilitation	
	No.	Costs (YR)	No.	Costs (YR)
Sana'a	7	7,192,575 (total) 1,569,000 (people) 1,623,575 (councils) 4,000,000 (other)	12	1,308,384 (total) 117,450 (people) 200,243 (councils) 990,691 (other)
Taiz	53	18,428,392 (total) 3,610,000 (people) 2,374,392 (councils) 12,444,000 (other)	3	40,450 (total) 1,000 (people) 39,450 (councils) -
Hodeidah	66	20,623,311 (total) 14,366,643 (people) 5,610,043 (councils) 646,625 (other)	10	131,450 (total) - 131,450 (councils) -
Ibb	86	4,097,647 (total) 1,340,603 (people) 2,526,044 (councils) 231,000 (other)	11	1,108,647 (total) 355,000 (people) 453,647 (councils) 300,000 (other)
Dhamar	6	2,116,837 (total) 1,213,450 (people) 903,387 (councils)	-	- - -
Hajja	19	5,723,111 (total) 573,879 (people) 1,146,232 (councils) 3,993,000 (other)	5	508,910 (total) 360,000 (people) 148,910 (councils) - (other)
Sa'ada	3	54,486 (total) - 54,486 (councils) -	3	33,750 (total) - 33,750 (councils) -
Beidha	19	1,439,042 (total) 908,400 (people) 530,642 (councils) -	22	683,098 (total) 475,000 (people) 176,098 (councils) 32,000 (other)
Mahweet	2	43,400 (total) 10,700 (people) 16,700 (councils) 16,000 (other)	-	- - - -
Marib	6	436,250 (total) 80,150 (people) 286,100 (councils) 70,000 (other)	- -	- - -
Jawf	-	- - - -	- - - -	- - - -
Total	267	60,155,051 (total) 23,682,825 (people) 15,071,601 (councils) 21,400,625 (other)	66	3,814.689 (total) 1,308,450 (people) 1,183,548 (councils) 1,322,691 (other)

(Source: CLCCD, September, 1987. Note that "other" refers primarily to foreign donor assistance.)