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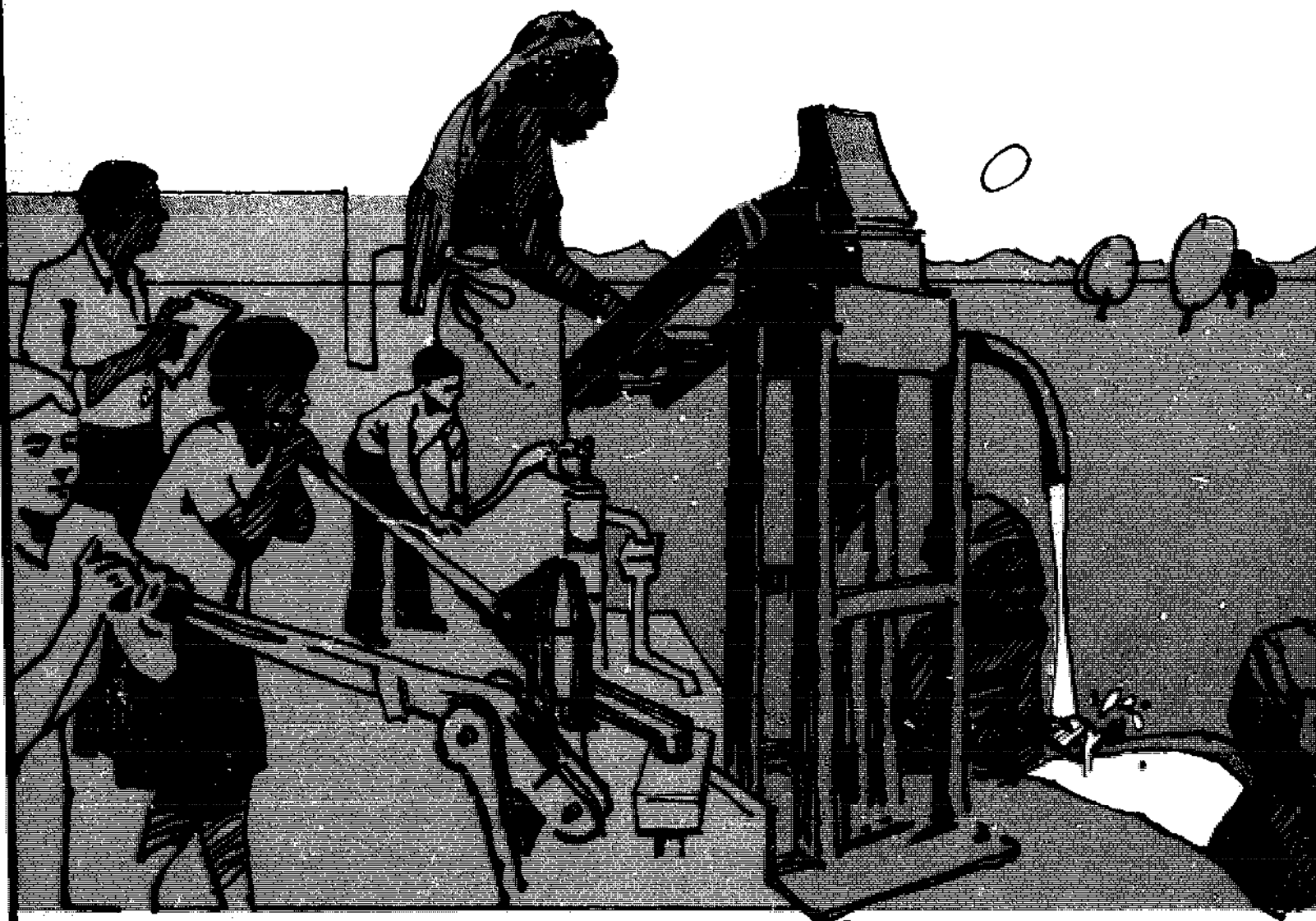
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Rural Water Supply Handpumps Project

Handpumps Testing and Development: Proceedings of a Workshop in China

Gerhard Tschannerl and Kedar Bryan, editors



UNDP Project Management Report Number 5

A joint contribution by the United Nations Development Programme and the World Bank
to the International Drinking Water Supply and Sanitation Decade

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(List continues on the inside back cover)

Rural Water Supply Handpumps Project

UNDP Project Management Report Number 5

RURAL WATER SUPPLY HANDPUMPS PROJECT

INT/81/026

The UNDP/World Bank project for laboratory and field testing and the technological development of handpumps for community water supply is aimed at promoting the use of suitable handpumps for groundwater extraction to meet the goals of the International Drinking Water Supply and Sanitation Decade. In the selection of pumps and in some cases their further development, consideration is given to their durability, capital as well as maintenance costs, suitability for village-level maintenance, and prospects for local manufacture.

Reports on handpumps testing and development are published periodically, at least once a year, for the duration of the project. The following reports have been or will soon be published.

- Report No. 1. Laboratory Tests on Hand-Operated Water Pumps for Use in Developing Countries: Interim Report. 1982.
- Report No. 2. Laboratory Evaluation of Hand-Operated Water Pumps for Use in Developing Countries. 1983.
- Report No. 3. Laboratory Testing of Handpumps for Developing Countries: Final Technical Report. 1984.
- Report No. 4. Handpumps Testing and Development: Progress Report on Field and Laboratory Testing. 1984.
- Report No. 5. Handpumps Testing and Development: Proceedings of a Workshop in China. 1985.
- Report No. 6. Handpumps Testing and Development: Interim Results. Forthcoming.
- Report No. 7. Handpumps Testing and Development: Malawi Case Study. Forthcoming.
- Report No. 8. Handpumps Testing and Development: Handpumps Compendium. Forthcoming.

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Handpumps Testing and Development

Proceedings of a Workshop in China

Gerhard Tschannerl and Kedar Bryan, editors

**Workshop on the State of the Art
and Application of Handpumps
and on Water Supply and Sanitation**

sponsored by

**Ministry of Machine Building Industry, China
United Nations Development Programme
The World Bank**

Changsha, China, August 15-21, 1984

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Gerhard Tschannerl and Kedar Bryan are senior project officer and editorial assistant, respectively, with the Appropriate Technology Unit in the Water Supply and Urban Development Department of the World Bank.

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ABSTRACT

The United Nations has declared the 1980s the International Drinking Water Supply and Sanitation Decade (IDWSSD) to address the needs of over 2,000 million people in developing countries who lack adequate supplies of safe water and sanitation facilities. The UNDP/World Bank Project for Laboratory and Field Testing and Technological Development of Rural Water Supply Handpumps is one of the activities being carried out as part of the Decade.

The objective of the Project is to support the global effort to provide reliable low-cost water supply systems to serve those in need of adequate sources of water in rural and urban fringe areas. Handpumps installed in dug wells or boreholes in areas where groundwater is available provide one of the simplest and least costly methods of supplying these areas with water. Emphasis has been placed on the development of pumps which are suitable for "Village Level Operation and Maintenance" (VLOM), as this may be the only sustainable and replicable option in most regions.

This report presents the proceedings of the "Workshop on the State of the Art and Application of Handpumps and on Water Supply and Sanitation", held in Changsha, Hunan Province, People's Republic of China, from August 15 to 21, 1984, as part of the Project's activities. The workshop was sponsored and conducted by the Ministry of Machine Building Industry of the Chinese Government, the United Nations Development Programme, and the World Bank. Funding for the workshop and project activities in China was provided in part by the German Ministry of Economic Cooperation (BMZ) and the German Agency for Technical Cooperation (GTZ) of the Federal Republic of Germany.

This report contains those papers submitted to the Workshop Secretariat and presented by representatives of developing countries and bilateral and international aid and development agencies participating in the Project activities. The major conclusions of the workshop and a short summary of the presentations are given in the Overview. The list of participants and workshop programme are provided in the annexes.

The report is intended to present those activities being conducted by select aid and development agencies and developing country governments as part of the Handpumps Project so that other agencies, governments and other interested parties might benefit from their experiences.

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PREFACE

One of the activities of the International Drinking Water Supply and Sanitation Decade is the UNDP/World Bank Project for Laboratory and Field Testing and Technological Development of Rural Water Supply Handpumps. As part of the Project's activities in China, a workshop on "Handpumps and Their Application in Water Supply and Sanitation" was held in Changsha, Hunan Province, from August 15 to 21, 1984. All the major assistance agencies which have contributed to the work of the Handpumps Project were invited to send participants. In addition, representatives from select developing countries in which the Project is conducting field trials of handpumps were invited to attend the workshop. However, not all the countries and agencies were able to send representatives, and the reports presented in this volume therefore constitute only a sample of countries active in the provision of rural water supplies.

Delegates from bilateral and international assistance agencies and developing country governments discussed their work in rural water supply schemes involving handpumps. Represented were the governments of Canada, the Federal Republic of Germany, Finland, India, Ivory Coast, Kenya, the Netherlands, the Philippines, Sri Lanka, Sweden, Switzerland, Thailand, and the United Kingdom. International organizations included the World Bank, the United Nations Development Programme (UNDP), UNICEF, the United Nations Environmental Programme (UNEP) and the International Development Research Centre of Canada. Eighteen provinces, municipalities and autonomous regions of China were also represented.

The workshop provided an opportune forum for a lively exchange of views and experiences between the foreign and the Chinese participants. In the words of a senior member of the Chinese delegation, the ultimate goal of the jointly conducted handpumps program in China is to develop a pump that can draw water from deeper, more reliable and cleaner sources than are now commonly used in China. A second aim is to improve the quality and introduce standardization of Chinese pump production, and to make spare parts more readily available. This program has led the Chinese government to participate in the UNDP/World Bank Handpumps Project, under which two field trials have been initiated in the Shanxi and Hunan Provinces and two pump-testing laboratories have been constructed in Beijing and Changsha. The governments of the Federal Republic of Germany and China have contributed \$500,000 each to the effort.

The workshop consisted of the presentation of reports, discussions and visits to handpump field trial and laboratory test sites in China. The papers presented herein are those submitted by participants of the workshop. Some papers have been edited for purposes of clarity and format. Those photographs, drawings, and diagrams which could be reproduced are also included in the individual papers. The views included in the papers are those of the authors. The major conclusions that arose from the presentations and discussions are given in the Overview, together with a short summary of the

papers that were presented. Reports given by members of the World Bank team are not reprinted here since they are contained in an expanded form in the latest progress report (Number 4) of the handpumps Project entitled Handpumps Testing and Development: Progress Report of Field and Laboratory Testing.

Comments on this report are most welcome.

Saul Arlosoroff, Chief
Applied Technology, WUD
(UNDP Projects Manager)

ACKNOWLEDGEMENTS

This report is a product of the World Bank-executed UNDP INT/81/026 Rural Water Supply Handpumps Project. Appreciation is therefore expressed to the World Bank, UNDP, bilateral funding agencies and Project Advisory Committee for their continued support and promotion of the Project activities, which have included the Workshop on the State of the Art and Application of Handpumps and on Water Supply and Sanitation.

We thank the Government of China--in particular the Ministry of Machine Building Industry, the Government of the Hunan Province, and the Chinese Academy of Agricultural Mechanization Sciences (CAAMS) for hosting the workshop from which these proceedings have been taken. We also express appreciation to all those individuals and organizations from China and throughout the world who participated in the workshop and contributed their time and effort to making it a success. Special gratitude must be expressed to the German Ministry of Economic Cooperation (BMZ) and the German Agency for Technical Cooperation (GTZ) of the Government of the Federal Republic of Germany who provided a large portion of the funding for both the Project's overall activities in China and the workshop. Last but not least, we thank Mr. Manfred Kulesa, UNDP Resident Representative for China, Mr. Albertus Sissingh, UNIDO Senior Industrial Development Field Adviser, and their staffs for their support.

The support of all these institutions, agencies and individuals is gratefully acknowledged.

SECTION 1

INTRODUCTION AND OVERVIEW

WELCOME

He Guangyuan
Vice Minister
Ministry of Machine Building Industry
Beijing, China

The Ministry of Machine Building Industry (MMBI) would like to welcome the participants of the "MMBI/United Nations Development Programme (UNDP/World Bank Workshop on the State of the Art and Application of Handpumps and on Water Supply and Sanitation" to China. We look forward to exchanging ideas and experiences with one another on issues relating to drinking water supply and sanitation.

Three-fourths of the world's population now lack clean water supply and adequate sanitation facilities. These problems are being addressed by the International Drinking Water Supply and Sanitation Decade (IDWSSD), launched by the 35th United Nations General Assembly on November 10, 1980. The Chinese Government is supporting the activities of the Decade through the MMBI in cooperation with the State Water Commission. China is making substantial progress in this area: the Government states that approximately 6.6 million additional Chinese benefit each year from water improvement schemes.

The Government's participation in the UNDP/World Bank Rural Water Supply Handpumps Project reflects further efforts to deal with the country's water supply problems. Progress has been made in both the laboratory tests being conducted by the Chinese Academy of Agricultural Mechanization Sciences (CAAMS) and the field trials being carried out in the Shanxi and Hunan Provinces. These activities are being funded in part by the Federal Republic of Germany through its Ministry of Economic Cooperation (BMZ) and Agency for Technical Cooperation (GTZ).

The activities of the Chinese Government during the IDWSSD reflect its open-door policy undertaken to further modernize the country and achieve the goals of the Decade. The Government believes that the exchange of ideas and experiences with other governments and organizations around the world through meetings such as the MMBI/UNDP/World Bank Workshop is one of the most effective methods of achieving these goals.

The Government of China wishes you all the success for a constructive meeting which will further enhance the goal of technology transfer and cooperation among the nations of the world.

OPENING ADDRESS

Zhou Zheng
Vice Governor
Hunan Province
Changsha, China

The "Ministry of Machine Building Industry/World Bank/United Nations Development Programme Workshop on Handpumps and their Applications in Water Supply and Sanitation" begins today. We are glad to host the meeting in Hunan. I, on behalf of the Hunan Provincial People's Government, extend to you our warm welcome and sincere congratulations on the convening of the meeting.

The United Nations' decision to carry out the activities of "Ten Years of International Water Supply and Environmental Sanitation" and realize in 1990 the goal of "Everyone Enjoying Safe Water Supply and Sanitation" has far-reaching significance. We hail it and support it. It plays an important role in improving the people's life, changing urban and rural appearances, protecting the environment, cutting down diseases, improving the people's health and promoting the development of production.

According to the bilateral cooperation agreement signed jointly by our Central Government, UNDP and the World Bank to set up the project of "the indoor and on-the-spot tests in China of water-supply handpumps and man-powered and animal-powered pumps in irrigation", the functional and durable tests of 12 man-powered and animal-powered irrigation pumps of 6 types are being undertaken in the Hunan Provincial Agro-Machinery Research Institute, and the tests of 138 handpumps of 10 types in water supply done in Changsha County, Wang Cheng County and the suburbs of Changsha. The work has been satisfactorily progressing. We are doing our utmost to carry out this job. We expect and appreciate your comments and suggestions. In order to vitalize the Hunan economy, we welcome the international participants to utilize Hunan resources and develop economic and technical exchanges and cooperations of various forms on the principles of equality and mutual benefit.

The workshop is a meeting of learning from and exchange with each other. It is as well a good opportunity for us to learn from the world the experiences in rural water supply and environmental sanitation. I am confident that the workshop will further promote the technical exchange and cooperation between the world's people.

OVERVIEW

CONCLUSIONS FROM THE WORKSHOP

The main conclusions reached from the presentations and discussions in the workshop are as follows:

1. The provision of wells and handpumps constitutes one of the most feasible solutions to the problem of inadequate water supply for the rural populations in the developing countries. This is increasingly recognized by developing country governments and assistance agencies, as large-scale rural water supply projects using handpumps are now being successfully implemented in Africa and Asia at a cost that is substantially less than conventional motor-driven systems.
2. The inclusion of community participation as an integral part of rural water supply projects is essential for the long-term success of the schemes. As the number of handpumps installed in a country increases rapidly, so does the demand for more mobile maintenance teams, unless workable provisions have been made for the village to assume the main responsibility for the maintenance of the handpump.
3. The VLOM (Village-Level Operation and Maintenance) system is the only reliable and affordable solution to handpumps maintenance in the long run. If the VLOM system is to be successfully implemented, a variety of factors have to be present, including a handpump technology that is suitable for village maintenance, a designated and trained caretaker, spare parts that are readily available nearby, cash collection for the spare parts in the village, and a back-up from the governmental or other implementing agency.
4. A training component must be included in all rural water supply projects. On the village level, a repairer is to be designated and given the necessary training and tools; on other levels, the technical, engineering, public health, and other manpower must be strengthened to raise the level of skills available for implementation and maintenance.
5. Quality control in manufacturing is a critical element for the success of the handpumps. In addition to quality control by the manufacturer, external quality supervision must be provided. Serial production of pumps in cottage industry workshops should be avoided since the required production quality can only be maintained by experienced manufacturers with a certain scale of operations.
6. Millions of suction handpumps are in use by single or extended families around the world, especially in China. In spite of their simplicity and low cost, they have some distinct disadvantages. One is the need for priming when the foot valve leaks, couples with the associated risk of polluting the well. Another is the gradual lowering of the groundwater table in many areas below the limit where the suction pumps can lift the water. Furthermore, when such pumps are used by larger user groups, they tend to wear out rapidly, and some of the parts are expensive to replace. Direct action pumps, i.e., reciprocating pumps without a lever, show great promise as an alternative to suction pumps, but are as yet not sufficiently tested and

demonstrated in field operations to be generally recommendable for large-scale implementation.

7. Plastic materials are increasingly used in handpump designs. Their chief advantages are low cost and corrosion resistance. Most of these applications, however, are still at the research and development stage, and the required manufacturing processes to make high-quality plastic products are often lacking in developing countries.

8. The design and completion of the borehole must be given adequate attention. Good pumps on bad boreholes are just as problematic as bad pumps on good boreholes. The choice of pump to be used in a particular area will depend to a large extent on the type of well and the number of users. The applications typically range from wells with very shallow water tables and a few users per pump to deep water levels with a large number of users. More attention must be paid to the cost of the borehole: It should be no more than the minimum required by the conditions.

9. Water quality plays an important role in water supply from wells. Problems frequently encountered are corrosivity (affecting pump parts and the rising main if made of iron), excess minerals (possibly resulting in a taste that is objectionable to the users), and surface pollution (i.e., organic materials or agricultural chemicals). Where such problems are suspected to exist, the water quality should be appropriately monitored and the design and completion of wells corrected to avoid problems to the degree possible.

10. Large-scale applications of handpumps, aside from rural water supply, are called for in some cases. These include human-powered, small-plot irrigation from shallow water levels--either used specifically for agriculture, in which case an ergonomically efficient pump should be used, or used for a small garden plot when water supply is the primary water use. Handpumps are also used in small urban (e.g., in China) or urban-fringe areas as an alternative to a motor-driven piped system.

11. The large-scale investment in handpumps-based water supply systems requires a well-integrated effort among the village community, the developing country government, and the assistance agencies. Donor agencies are committed to continuing their contributions in order to assist in the accelerated implementation of such programs.

COUNTRY AND ASSISTANCE AGENCY ACTIVITIES

The following are brief summaries of the presentations given during the workshop, except for the welcome which was delivered by He Guangyuan, Vice Minister of the Ministry of Machine Building Industry and the opening and closing addresses which were given by Mr. Zhou Zheng, Governor of the Hunan Province. A summary of the presentations by the team members of the Handpumps Project is given in the end. For a complete report on the Handpumps Project, please refer to World Bank Technical Paper No. 29, Handpumps Testing and Development: Progress Report on Field and Laboratory Tests (UNDP Project Management Report No. 4, 1984).

Canada

Linda J. McDonald, Canadian International Development Agency (CIDA). CIDA has supported water projects for many years; as of 1982, CIDA has provided more than 350 million USDollars to such projects. The agency has recently financed portions of three of the UNDP/World Bank Global/Interregional Projects in support of the International Drinking Water Supply and Sanitation Decade (IDWSSD): (1) the Information and Training Program in Low-Cost Water Supply and Sanitation (CIDA contribution of 550,000 USDollars to Phase I); (2) the Integrated Resource Recovery Project in the Ivory Coast and India (promotion of biogas research); and (3) the Handpumps Project in Bangladesh (analysis of the effects of water, sanitation and education on health), Ivory Coast (assistance to the Government in its efforts to decentralize the entire management system of handpump installation, operation and maintenance to the villages), Ghana and Sri Lanka (testing of handpumps). CIDA contribution is 1 - 4 million USDollars. CIDA is supporting the UNDP/World Bank Handpumps Testing Program for a number of reasons:

1. Because of CIDA's traditional support of water projects;
2. In order to encourage the development of standardized testing methodologies using verifiable data;
3. Because of CIDA's interest in an integrated approach to water supply programs;
4. Because the UNDP/World Bank Project incorporates the concern related to villager involvement in handpump programs, an essential element to all such activities.

CIDA announced at the Workshop that it has just completed negotiations with the Government of China for the provision of 10 PEK (plastic) Canadian handpumps for inclusion in China's laboratory and field testing activities.

Donald S. Sharp, International Development Research Centre (IDRC). Since 1976, IDRC has supported research in the development of more effective pumping systems for rural water supply. The approach taken has been to systematically examine the implications of improved pump designs and new materials. The IDRC-sponsored research centered on foot valves in an effort to save labor costs in manufacturing, simplify maintenance procedures and keep the required number of spare parts to a minimum. The research results of four projects in Asia and two in Africa demonstrated that the pump is reliable, durable and suitable for local manufacture in developing countries. In 1983, the University of Malaya began a research project to investigate the mass production of below-ground components by injection moulding of plastics. Important social, cultural and economic issues essential to promoting acceptance of the technology at the village level are also being examined. The Malaysian project is the focal point of a Phase II network of projects currently investigating manufacturing options, financing and maintenance schemes and development of appropriate educational materials. By encouraging researchers to examine field tests and adapt the PVC pump to local conditions according to needs, available expertise and materials, IDRC aims to promote the local manufacture of more reliable pumping systems and encourage self-reliance at the community level.

Federal Republic of Germany

Werner Knipschild, German Ministry of Economic Cooperation (BMZ). The Government of the Federal Republic of Germany, through its Ministry of Economic Cooperation (BMZ), has set a suprasectoral target of meeting basic needs in the developing world, which includes the provision of safe drinking water and adequate sanitation systems. The German Government has increased its support for water supply and sanitation measures from 3 percent to 4.5 percent since the beginning of the IDWSSD and is actively promoting the use of simple appropriate technologies, such as handpumps, suitable for local conditions. In an effort to further the available knowledge of handpumps technology, the German Government is supporting laboratory and field tests being conducted by the Government of China, the World Bank and UNDP. Based on its development policy, the German Government is seeking to achieve two aims: (1) to make German know-how of handpumps technology available to the Chinese, and (2) to make Chinese experience and advice available to other Third World countries.

Hinrich Eylers, German Agency for Technical Cooperation (GTZ). The GTZ, as executing agency of the Federal German Government for its bilateral technical cooperation programmes, is involved in more than 60 water supply and sanitation projects in more than 30 developing countries. The new technical cooperation project with Chinese Academy of Agricultural Mechanization Sciences (CAAMS) of China on developing and testing suction and deep-well handpumps will integrate Chinese know-how and experiences into the Decade activities and also improve technical cooperation among developing countries. The primary emphasis within the GTZ concept of the Decade is given to users' participation in planning and implementing rural and urban-fringe handpump water supply and sanitation projects. This includes training of technical and administrative staff on all levels and hygiene education programmes for the communities, with special emphasis on the important role of women in the families. One of the main targets is the installation of economically and technically sound pilot projects on a self-sustaining and self-help basis in an effort to convince the population of the advantages of projects of their own and to strengthen local manufacturing and skills for production, operation and maintenance of the necessary equipment.

Finland

Kari Homanen, Finnwater. The Government of Finland has assisted the developing countries of Tanzania, Sri Lanka and Kenya in the development of their rural water supply sector. Approximately 1,700 wells have been constructed as part of the Tanzania Project; the wells serve about 400,000 people. The Project is now creating village-level systems for the operation and maintenance of handpumps/wells, already having turned over the maintenance responsibilities in 70 villages. The Project, in close coordination with World Bank experts, has also developed a direct action pump made by skilled local workers using primarily imported materials. The Nira pump manufacturer at FINNIDA has also introduced a new direct action pump constructed mainly of plastic materials. The Project, in cooperation with local health authorities, has prepared a poster series and a booklet about water and health; it will stress the sanitation component in the near future, with a pilot program being planned for implementation in 1985.

India

Holenarasipur V. Krishnaswamy, Government of India. In keeping with the goals of the IDWSSD, the Government of India has set a target of providing 100 percent of its population with protected water supply by March 1991. One of the methods of achieving this target is the installation of deep-well handpumps in urban-fringe and rural areas. India has adopted the India Mark II handpump as the standard deep-well handpump for the entire country. In eight years since the implementation of this standardization, over 440,000 Mark II pumps have been installed, and this figure is expected to reach one million by March 1991. The Government has produced national standardized specifications for deep-well handpumps and their installation and maintenance. Improvements in the India Mark II are continually incorporated into the national specifications.

Ivory Coast

Anzeni Djouka, Direction Central de l'Hydraulic. The national policy of the Ivory Coast concerning the supply of drinking water to the population encompasses the entire country and has been realized by 80 percent of the population. The program includes 11,000 water points, of which one-third are large diameter wells (600-800 mm) with depths varying between 15 and 30 m; two-thirds are drilled wells with depths varying between 25 and 100 m. Three types of pumps are used in the country, of which the two latter are manufactured in the Ivory Coast: the hydraulic Vergnet pump, the ABI, and the ASM, which has been tested in the laboratory and in the field by the UNDP/World Bank program. With the aid of CIDA and the World Bank, an organizational structure will be established to coordinate and manage the different activities necessary for maintaining and repairing pumps, as well as training villagers to take the responsibility for repairing and obtaining spare parts for their pumps.

Kenya

Daniel M. Kirori, Minister of Water Development. The area of Kenya is 225,000 square miles, one-third of which has adequate rainfall; the remainder of the country is arid or semi-arid. The national objective of Kenya's Government is to provide good water to the entire nation by the year 2000. Because of the hostile climatic conditions, problems with the large variety of imported equipment and materials, and lack of spare parts, fuels, financing, technical expertise and local participation, only about 40 percent of the population now has access to good clean water. Kenya plans to provide a large percentage of the rural population with water from wells fitted with handpumps wherever possible. Several handpump pilot projects are underway in an effort to achieve this target objective. Rural health programs are incorporated in the rural water supply projects, as well as provisions for sewage facilities, local participation and local manufacture.

The Netherlands

Gert Jan Bom, Netherlands Development Cooperation. The Netherlands is currently involved in about 100 water supply projects involving an average annual expenditure of 65 million USDollars. Following its priority concern of

socioeconomical and sanitation issues, the NDC has an intensive interest in the development of handpumps which can be kept operational for many years under the prevailing circumstances. To this effect, three pumps have been developed by the NDC: the Bandung Shallow-well Pump in Indonesia, the SWN Medium-Lift Pump in Tanzania and the Volanta High-Lift Pump in Upper Volta. It is the Volanta pump that appears to be the most promising with regard to village-level maintenance and repair, as the pump cylinder can be extracted without special tools and with only minimal skill. The development of the Volanta pump has taken place in Upper Volta, enabling a direct feedback from the field experience to the designer/manufacturer. After four years of development, the Volanta pump is believed to have become a mature product, bringing the goal of village-level maintenance closer to reality.

China

Chen Zhuo Han, Fujian Turbine-Pump Research Institute.

Approximately eight million people in the Fujian Province located in southeast China do not have a safe supply of drinking water, while an additional three million face a shortage of safe water. The Fujian Turbine-Pump Research Institute, under instructions from the Fujian Machinery Bureau, has developed and tested low-priced manually operated shallow-well pumps for drinking and irrigation of small fields. Handpumps have also been developed for installation along rivers, brooks and ditches. The Fujian Turbine-Pump Research Institute is also stressing international cooperation and technical exchange among developing countries. Simultaneously, an enterprise standard has been formulated regarding specifications for quality, performance and acceptance tests of the handpumps.

Feng Bingyuan, Chinese Academy of Agricultural Mechanization Sciences. Handpumps are still widely used throughout China and may be categorized as shallow-well, deep-well and water-lifting from rivers and ponds. As China handpump factories are widely scattered, standardization is urgently needed. An agreement has been reached by the Chinese Government, UNDP, and the World Bank (Project INT/81/026) to implement handpumps testing and develop both human-powered water-lifting devices for small-plot irrigation and handpumps for drinking water available at depths of up to 50 metres. A handpump laboratory has since been established at the Chinese Academy of Agricultural Mechanization Sciences (CAAMS). In addition, 24 types of pumps will be tested in the field by personnel trained by CAAMS engineers and World Bank staff members. Use of well-drilling equipment, both motorized and manual, has also become more commonplace in China; such equipment may be divided into rotary and punching types.

Li Jiuru, National Water Improvement Action Committee and Central Patriotic Health Campaign Committee. The Chinese Government is fully committed to the goals of the IDWSSD. In the urban areas of China, 85.2 percent of the population now has tap water available to them, while 40 percent of the rural population has benefited from improved water supply. The efforts of the Government in the 1980s has been to further improve simple-styled piped water supply systems called rural running water for bringing water to the households. Despite this progress, problems with drinking water supply are numerous, with such problems being quite urgent for approximately 300 million people. In meeting the needs of its population, the Chinese experience in water supply has emphasized the following: (a) greater

understanding and a strengthened lead function; (b) investigation of water sources and quality; (c) works run by the local people and subsidized by the Government; (d) stress on miscellaneous forms and practical results; and (e) attention to personnel training and strengthening of management.

Xiao Yi-Bai, Bureau of Mechanical Industry. The Bureau of Mechanical Industry is involved in the production of a large variety of machinery and equipment: agricultural machinery, electrical equipment, automobiles and parts, machine tools, mining equipment, meters and instruments, ball bearings, packing machines, and general machinery for everyday consumers. A total of 4,000 variations of products are now produced under its direction at the Hunan Research Institute of Mechanical Engineering. In organizing developing countries for the production of high-quality, low-priced handpumps, the Bureau is stressing the policy of mass production, based on the concepts of standardization, simplification, and specialization, and the promotion of such mass production.

Zhang Shaoxin, Peoples Government of Jincheng City. The city of Jincheng in the Shanxi Province is one of the sites selected for handpumps field trials in China under the UNDP/World Bank Rural Water Supply Handpumps Project. Various steps have been taken to implement the field trial: establishment of a Spot Test Office to deal with the daily work involved in the Project; selection of 153 well sites in the area of the city; training of 145 local workers to maintain, operate and monitor the wells; and installation and monitoring of the handpumps, 27.4 of which have been received thus far. Experiences in Jincheng City have emphasized the need for acceptance of the handpumps by the users involved, a system of personal responsibility for handpumps operation and maintenance, and close coordination among all persons and organizations involved in the handpumps systems.

The Philippines

Florencio F. Padernal, Ministry of Public Works and Highways. The most widely used water supply source in the Philippines is groundwater extracted from wells and springs. For the basic level of water service, three general types of wells are used in the country: shallow, intermediate and deep. Shallow wells are fitted with cast-iron suction pumps (single-purpose or multi-purpose), with either 38-mm diameter PVC casing pipes and screens or 50-mm diameter GI casing pipes and well points. These types of wells are applicable in areas where the water level is no more than six meters deep and the wells serve an average of 30 households. Intermediate wells are fitted with 46-mm diameter cylinder pumps and 10-mm diameter pump rods on 50-mm diameter GI casing pipes with well points and wooden handles. These wells are suitable in areas where the water level is 6 to 30 meters deep. They can serve up to 50 households. Deep wells have large-diameter steel or black iron casing pipes and screens, suction pipes with cylinders, pump rods and wooden handles. They are applicable in areas with more than a 30-meter water level. These wells can eventually be upgraded to communal faucet systems or water works/individual tap systems.

Sri Lanka

Kiribanka B. Eoyagoda, National Water Supply and Drainage Board. In Sri Lanka, the handpump installation project began in 1979 with the aid of

UNICEF. Under the project, all well locations are proposed by the community, and those sites are investigated by a geologist before drilling. All community wells in the dry zone are 35 to 75 meters deep; the suction pipes are installed at an average depth of 36 meters. The India Mark II has been the best performer of the pumps in the project, with its only disadvantage being the necessary removal of the column pipes for repairs in the cylinder. There are a few projects in existence to upgrade the traditional open dug wells and equip them with handpumps. There is also a pump-testing program in one of the districts. Voluntary caretakers are given training; pump mechanics are kept at the district center to attend to those pump breakdowns reported by the caretakers.

Wimaladharma Ekanayaka, Sri Lanka Administrative Service. A special UNICEF project is being conducted in the Kalutara District by three assistant government agency divisions. The health and sanitation project includes latrine construction and nutrition and population planning. The project is to be implemented through gramodayas--village-level voluntary planning and implementing agencies. Sarvodaya, the largest non-governmental organization (NGO) in Sri Lanka, is interested in handpumps and has devised its own model with international assistance. These pumps are being tested by UNICEF in the testing program as part of the project. Maintenance of pumps is carried out by gramodaya members after training by UNICEF. Self-reliance is stressed in pump maintenance so that villagers are less dependent on outside sources for assistance.

Sweden

Rolf Winberg, Swedish International Development Agency (SIDA). Sweden has been involved in development cooperation activities since 1960, primarily in Africa, but also in Asia and South America. The annual multilateral and bilateral contribution is approximately 800 million USDollars, of which the rural water sector receives approximately 25 million USDollars annually. Inadequate water supply is only one of the problems experienced by rural communities; therefore, solutions must be based on an integrated approach. Sweden prefers to participate in integrated water programs in a few countries rather than support a high number of water projects scattered throughout many countries. Swedish assistance is directed at two levels:

1. The central level--institutional developments, planning, research, training, and other crucial functions;
2. The area level--a geographically agreed-upon area, such as a province or district. An area program aims at a high degree of self-reliance and consumer participation. It may emphasize mobilization of consumers, technically sound water supply (often wells with handpumps based on the VLOM concept), health/hygiene education, sanitation, environmental protection, improvement of traditional water sources, economic aspects, garden irrigation, general water use, human resources development, etc.

Switzerland

Arnon Hartmann, Swiss Development Cooperation (SDC). The policy of the SDC is based on assistance to the underprivileged groups in the Third World, e.g., the rural population sector addressed by the Water Decade. The SDC considers the cooperation and contribution of the local communities as one of the most important aspects during the planning, preparation and execution of the projects. When choosing handpumps for a project, consideration is given to those pumps already installed, in order to keep the variety of handpumps installed to a minimum. Because of the number of information sources, it is very difficult to determine the exact and current data on the state of the art and application of handpumps at any given time. The SDC therefore suggests, that in the interest of the different parties concerned, be they donor or recipient countries, current information on the actual state of the art and application be prepared and distributed at regular intervals.

Thailand

Chetpan Karnkaew, Ministry of Public Health. Thailand has an area of 514,000 square km, with a population of 42 million of which 80 percent live in rural areas. The Basic Minimum Need (BMN) for drinking water is 2 l/d/c, while the BMN for water for general domestic use is 30 - 35 l/d/c in the rural areas. The provision of clean water for drinking and domestic use in the rural areas was set in the government policy based on the following priorities: (1) rainwater collection; (2) shallow dug wells; (3) deep wells; and (4) piped water systems. There are two handpump prototypes in Thailand: the Korat Handpump and Dempster Modified Handpump. About 52,000 deep-well handpumps have now been installed; about 15 percent are out of operation. The failures of the handpumps are primarily caused by poor handpump design, lack of management for maintenance and funding, and shortage of funds. To solve these problems, the Korat 608-C and PVC Deep-well Handpumps are being developed and monitoring has begun.

United Kingdom

M. Brian Grieveson, British Overseas Development Administration (ODA). The four primary lessons learned by ODA officials from their experiences and mistakes made in rural supply schemes are as follows:

1. Equipment must be designed to fit in with the social and cultural attitudes of the users.
2. New hardware put into the field must quickly gain the confidence of the users as reliable.
3. Designers of equipment must always keep in mind the low degree of technical skill which will be available for maintenance.
4. The entire well or borehole must be considered (not only the pump) where more development work is needed to reduce construction and performance costs.

Kenneth J. Mills, Consumers' Association Testing & Research (CATR). The Consumers' Association was founded in the United Kingdom in 1956 to carry out product testing, comparing the results to manufacturers' and importers' claims. In 1977, the Overseas Development Administration (ODA) of the United Kingdom contracted the Testing and Research Laboratories of the Consumers' Association (CATR) to test various handpumps, which ODA often found unreliable in its developing country projects. The World Bank/UNDP has continued this evaluation work, with 36 handpumps having been evaluated thus far; results have been published by the World Bank as three technical papers. Activities of CATR as part of the INT/81/026 Project have also included water flow monitor development; Maldev pumphead development, in particular the dry bearings and pump cylinder; the investigation into the viability of plastic below-ground components, in particular, plunger and foot valves, pipe connectors and moulded components; and lightweight pumprod development. CATR is continuing to actively participate in the INT/81/026 project.

United Nations Children's Fund (UNICEF)

Martin Beyer, Drinking Water Supply and Sanitation Section, New York. UNICEF has been involved since 1949 in water supply projects to aid the least privileged populations. In 1983, UNICEF cooperated with 93 countries in their rural and peri-urban water supply and sanitation programmes. This involvement has included the use of low-cost technologies--principally handpumps--for both reaching water sources, primarily groundwater, and for water lift. UNICEF is now cooperating with the UNDP/World Bank Interregional Handpumps Testing and Development Project (INT/81/026), where it is stressing technological development and inputs as parts of an integrated approach, with a good balance between the technical and social components. Its work is entirely oriented towards the users and involving their participation at all stages and with the necessary concern for their environment and the handling of the equipment for the technical designs involved. One of the major outputs of the UNICEF program was the development in India of the India Mark II deep-set (lift-mode) handpump. UNICEF is now working jointly with other agencies and bodies of the U.N. system to encourage country- and community-based activities as part of the IDWSSD.

Rafael Diaz-Diaz, Sri Lanka. UNICEF has assisted the Government of Sri Lanka in the implementation of several development programs, including the deep-well handpumps project. The Government became interested in the project when UNICEF imported the first down-the-hole hammer rigs. For this new technology, deep wells were constructed in the hard rock. The primary constraint to the handpump testing program is the people's lack of interest in the use of handpumps. A program of health education, conducted by the Scouts Association, has begun in an effort to overcome this problem. Another constraint is the iron content of some of the water: iron treatment plants are being used to combat this problem.

Kenneth Cray, India. The following lessons learned from India's experience with deep-well community handpumps (India Mark II) may benefit China and other developing countries:

1. Deep-well areas should be given priority for handpump development and government implementation.

2. The handpump is only one element of a system which includes the borehole, handpump, installation and maintenance tools, maintenance infrastructure and training material; all these elements should be developed simultaneously.
3. National specifications and standardization of a handpump design should be developed.
4. Production units should be developed in each province.
5. All community handpumps should undergo quality assurance pre-delivery inspections.
6. There should be a mechanism for incorporating design improvements into the specifications and production.

United Nations Environment Programme (UNEP)

Letitia Obeng, Kenya. Being a complex problem affecting various aspects of development, especially in rural areas, the installation of water supply facilities must take into account the potential presented for dealing with other problems related to unsatisfactory water supply, especially water-related diseases. Integrated rural water supply incorporating effective supply systems, health education, and control of water-related diseases is the preferred strategy. Water supply systems should aim at providing permanent solutions; piped water should be seen as the long-term solution. All forms of supply sources, however, should be explored and used according to the conditions of the region of installation. Handpumps have a special role to play, since there are regions where groundwater provides the only reliable source of water, but they are not the only solution to the water supply problem. The UNDP/World Bank Handpumps Project is therefore important in assisting with the development of reliable water supply. Almost all the serious health problems of rural developing countries are water-related. Adequate water in quantity at home or near the home is absolutely necessary to control most enteric infections. It is immaterial whether the water is delivered by handpumps, piped systems or rain water. They must all be used wherever feasible to keep people away from infected sources. The involvement of people being assisted is absolutely essential, no matter what supply system is proposed. It is possible to involve people through consultations, encouragement and the development of a feeling of responsibility for water supply programs. When reliable handpumps are ready to be widely installed, national consultations and the involvement of the people must be seen as a key component activity.

SECTION 2

RURAL WATER SUPPLY IN CHINA

APPLICATION AND TESTING OF HANDPUMPS IN CHINA

Feng Bingyuan
Vice Director and Chief Engineer
Chinese Academy of Agricultural
Mechanization Sciences
Beijing, China

I am pleased to have this opportunity to present the topic of production and use of handpumps in China, and of the work carried out as a part of Project INT/81/026. Also, I would like to say a few words on China's well-digging devices.

THE PRODUCTION AND USE OF HANDPUMPS IN CHINA

Since 1949, the founding of New China, the Government has attached great importance to the development of water-lifting devices. A good variety of human- and animal-operated pumps have been evaluated or recommended at national and provincial levels. All of them are simple in structure and low in cost, and therefore, they are well received by the masses of peasants.

In May 1983, the Chinese Academy of Agricultural Mechanization Sciences (CAAMS), together with members of institutions in Hunan, Fujian, Sichuan, Shandong, Inner Mongolia, and other provinces, carried out a survey covering twenty-five provinces, municipalities, and autonomous regions in China, on the production and use of handpumps. The results of the survey show that although the human- and animal-operated water-lifting devices in some places have been replaced by motor pumps, the former are still widely used for drinking water supply and irrigation water replenishment. Not only in the villages, but also in the small towns, handpumps provide drinking water for the residents.

The use of handpumps is very widespread. According to incomplete statistics, there are 3,400,000 handpumps in use in Henan, 2,740,000 handpumps in Shandong, and 1,250,000 handpumps in Hebei. Shandong's Juye County has 54,000 handpumps, averaging one pump for every two households. In Sichuan's Chongqing County, 90 percent of the rural population use handpumps. By 1983, in Anhui's Fuyang Prefecture alone, there were 1,140,000 handpumped wells benefiting crop production.

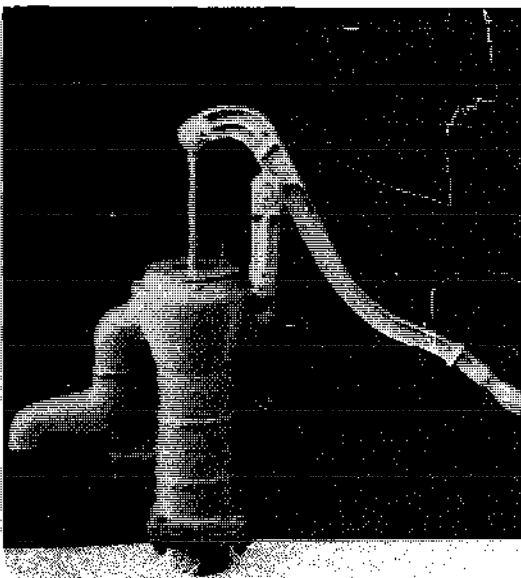
Among the 80 types of handpumps surveyed, there are 25 types of single-piston pumps; 2 types of triplex-piston pumps; 2 types of fourplex-piston pumps; 14 types of diaphragm hand-press pumps; 4 types of push-pull double-acting handpumps; 14 types of crank/pedal centrifugal pumps; 3 types of tube-chain water wheels; 4 types of deep-well pull-rod pumps; 3 types of screw-rod pumps; and dragon-bone water wheels. These pumps comprise the varieties and manufacturing level of handpumps currently produced in China.

China's handpumps are usually divided into three types according to the sites where they work:

Shallow-well Handpumps

Shallow-well pumps are used where the suction head is less than 8 metres. Essentially, they provide drinking water for peasants and animals. They are very simple in structure, and, in general, are conveniently located in the courtyards or just next to the stove at the front or back of the house.

The single-piston pump is the most popularly produced handpump. The Model SYB-100 handpump (Figure 1) produced by the Changsha County Light Machinery Plant in Hunan, the Model SY-81 handpump (Figure 2) produced by the Dayu County Farm Machinery Plant in Jiangxi, and the Model 8SYB-80 handpump (Figure 3) produced by the Yunxiao County Farm Machinery Plant in Fujian are examples of single-piston pumps.



SYB-100型手搖式吸水泵

FIGURE 1 SYB-100 HANDPUMP



FIGURE 2 SY-81 HANDPUMP

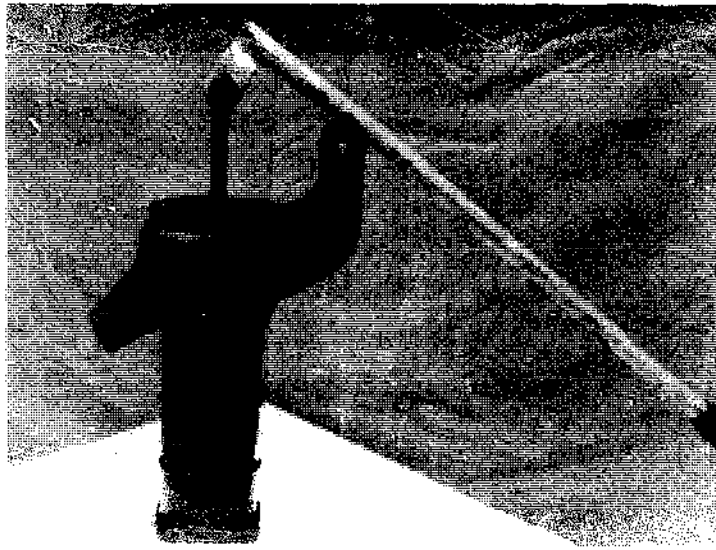


FIGURE 3 8SYB-80 HANDPUMP

The Model SB-80 single-piston hand-press pump, produced by Jiexi County Farm Machinery Plant in Guangdong, weighs 6 kgf and is equipped with a one-inch diameter suction pipe. By 1983, 46,519 SB-80 pumps had been sold, and the price was 17.5 percent lower than in 1982.

According to the survey recently carried out, only six county-level plants, namely, Changsha County Light Machinery Plant in Hunan, Yunxiao County Machinery Plant in Fujian, Dongfeng Farm Machinery Plant of Jing County in Hebei, Jiexi Farm Machinery Plant in Guangdong, Suining County Farm Machinery Plant and Chengguan Farm Machinery Plant of Chongqing County in Sichuan, produced a total of more than 200,000 handpumps in the past few years.

Deep-well Handpumps

China's groundwater sources are unevenly distributed. In the South, they are relatively shallow, most less than 10 metres deep and generally ranging from 3 to 5 metres. Water is deeper in the North, generally from 10 to 15 metres, and as much as several hundred metres in a few places in the Northwest. Therefore, the utilization of deep groundwater for drinking and irrigation has been a problem all through the ages. In the past, the hand-operated "lulu" has been used as the deeper water-lifting device. However, in the 1950s, the Model Liberation tube-chain water wheel underwent appraisal by the Government and became popular in the rural areas. There are two types of tube-chain water wheels, as shown in Figure 4. One tube-chain water wheel can irrigate farmland up to 40 mu. The tube-chain water wheel has played a significant part in drinking water supply and farmland irrigation, as it can lift water from a depth of ten metres. According to the statistics, Hebei had 2,700,000 human- and animal-operated pumps, of which most were tube-chain water wheels.

As the groundwater level in many places such as Henan and Shandong Provinces became deeper due to drought, many of the peasant users modified their shallow-well handpumps in order to use them as deep-well pumps (Figure 5). The working principle and structure of the modified pumps remained the same as the shallow-well pumps, but the upper rod was elongated and the body of the pumps went down to meet the water-lifting height. The total lift can reach 20 metres.

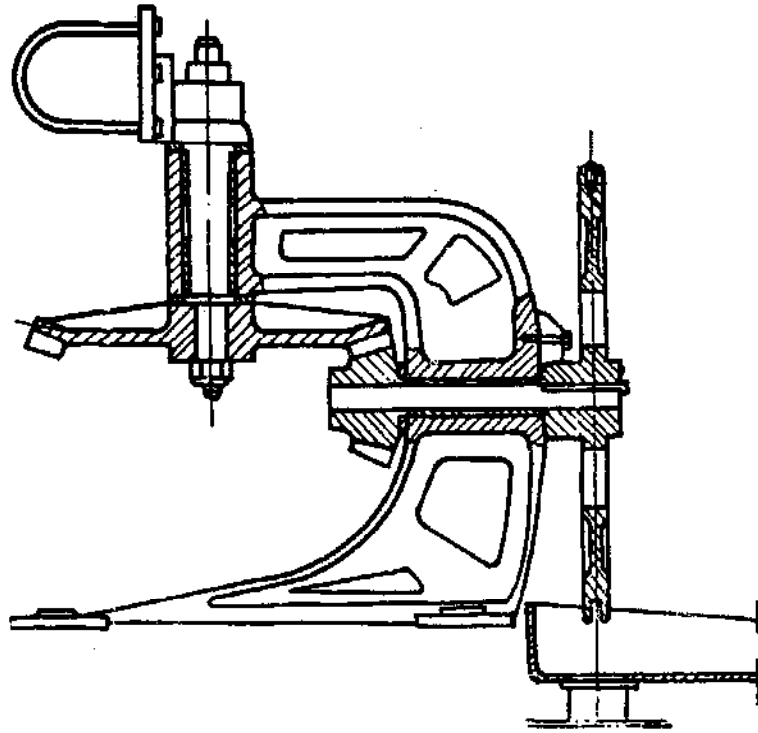


FIGURE 4 LIGHT LIBERATION-TYPE WATERWHEEL OPERATED BY HUMAN OR ANIMAL

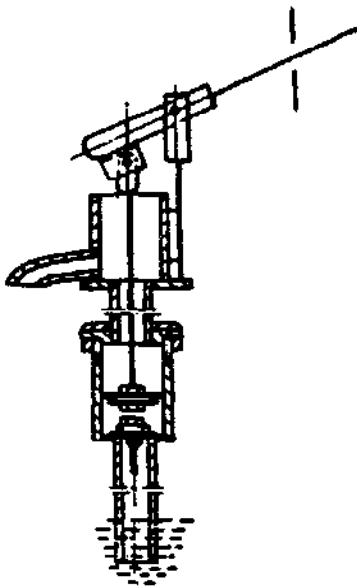


FIGURE 5 MODIFICATION OF THE SHALLOW-WELL HANDPUMP

A deep-well pump is now being developed in China. Recently, the Taian Water Pump Plant of Shandong, the Miyun County Farm Machinery Repairing and Manufacturing Plant of Beijing, and the Gaoping County Farm Machinery Plant of Shanxi have been jointly developing the Model SLB-80 pull-rod pump for deep wells (Figure 6). It has a flow rate of $1.2 \text{ m}^3/\text{hr}$ and a head of above 20 m. The Model 30SLB 0.5-1 screw-rod handpump for deep wells (Figure 7) is being jointly developed by the Shanghai Deep-well Pump Plant and Pinghu County Farm Machinery Plant in Zhejiang Province. The flow rate of this pump is $0.6 \text{ m}^3/\text{hr}$, and the head reaches 20 metres or more. Fifty-eight prototypes of these handpumps for deep wells are now being field tested. The newly developed handpumps will also be tested in the Handpump Laboratory in CAAMS as models are selected.

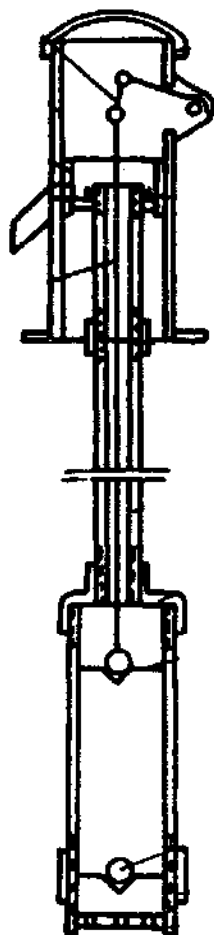


FIGURE 6 PULL-ROD DEEP-WHEEL
HANDPUMP

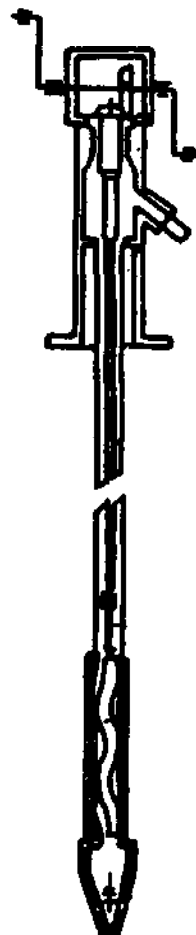


FIGURE 7 SCREW-ROD DEEP-WELL
HANDPUMP

Handpumps for Rivers and Ponds

The types of handpumps lifting water from rivers and ponds are mainly the diaphragm pump, duplex piston hand-press pump, animal-drawn four-plex piston pump, crank/pedal centrifugal pump, and dragon-bone water wheel and tube wheel.

The diaphragm pump is applicable for both drinking water and irrigation. It has greater discharge and is suitable for simple tube wells and other water sources, even if the water is turbid.

The Model MB-290 diaphragm pump (Figure 8), produced by the Tongan County Farm Machinery Plant, is operated with a method combining hand, push-pull and pedal methods in order to reduce the toil of the operator.

In the South, the most commonly used pumps for irrigation are crank and pedal centrifugal pumps. Many plants produce this type of pump. For example, the Anyue County Machinery Plant produces the Model SB pedal centrifugal pump (Figure 9). The pump is accelerated through an accelerating gear. There are three grades for this pump--popular, medium and high. They have been warmly received by the peasants. Also, 100 units of this pump have been exported to Africa. Some factories mount a centrifugal pump onto a bicycle or a rice thresher to make a bike-pump or rice thresher-pedal pump.

The Model 8BM-300 diaphragm pump (Figure 10), produced by the Xiangcheng County Machinery Plant in Henan, is very competitive due to its higher capacity and lower price. The basin-shaped case of the pump is stamp-cold or cast-formed. The diaphragm works at a frequency of 30-50 strokes per minute. The pump has a flow rate of 7 to 11 m³/hr. The diaphragm has undergone an endurance test for more than 1,500 hours. Nearly ten thousand pumps of this model have been sold since it was developed a year ago.

A handpump can be used as a manual sprinkler when a special nozzle is mounted. Jiangxi, Shandong, and Henan are producing handpump sprinklers.

The dragon-bone water wheel, an age-old traditional water-lifting device in China, is still used for irrigation and drainage in the South and the coastal areas. The useful life of a dragon-bone water wheel may be up to ten years, if carefully used.

Another traditional water-powered water-lifting device for mountainous and hilly areas in the South is the so-called tube water-lift. It is made of bamboo and wood, has a larger diameter and is very simple in structure. No operator or monitor is needed when it is working. The tube water-lift is applicable to where the head is low (0.2 to 0.3 metres) and the flow rate is rather large (0.7 to 5 m³/hr). The head can be 1 to 30 metres.

Future Development of Handpumps

It is far from enough to irrigate farmland only with hand-operated and animal-operated water-lifting devices. Therefore, motor pumps have been developed where conditions permit. At present, there are 520,000 pumping stations and more than 2,300,000 motor-pumped wells over the country. There are 4,805,000 pumps used in agriculture. The total power for irrigation and

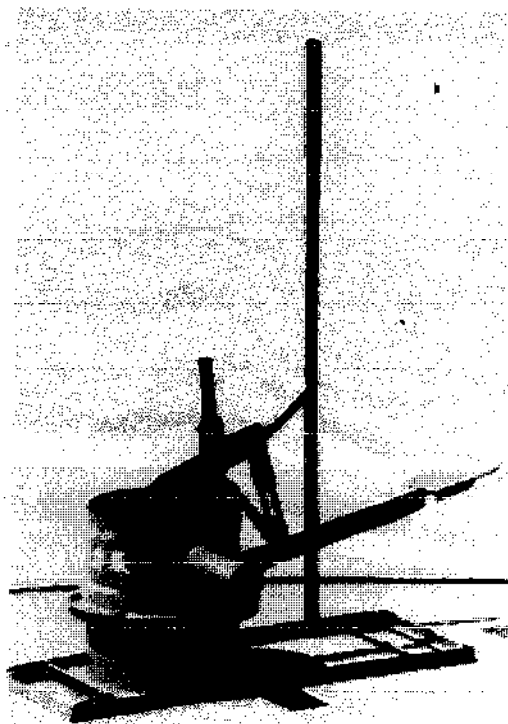


FIGURE 8 MODEL-290 DIAPHRAGM PUMP



FIGURE 9 MODEL SB PEDAL CENTRIFUGAL PUMP

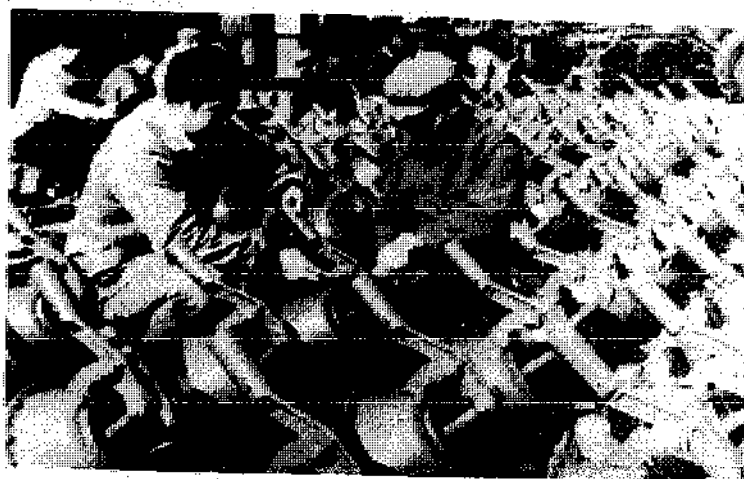


FIGURE 10 MODEL 8BM-300 DIAPHRAGM PUMP IN ASSEMBLY

drainage amounts to 77,000,000 hp, of which 36,100,000 hp are diesel. Nearly 400 million mu of farmland, i.e. more than 50 percent of the total area under irrigation, are motor-irrigated.

The simple-structured handpumps, however, are still indispensable for the areas lacking electricity and petroleum fuel. Pumps operated by man, animal, wind, and/or water power are also of great importance to other developing countries due to the worldwide energy shortage.

According to statistics from the United Nations, 1,100 million persons in rural areas of developing countries (excluding China) are lacking an adequate supply of safe water. It is estimated that the rural population requiring safe potable water will amount to 2,000 million by 1990. Handpumps are the most desirable water-lifting devices as they are cheap, simple in structure, and easy to operate and maintain. In China, the Government encourages the application of handpumps in areas where running water stations are difficult to build at present. In Shanxi, for example, the Provincial Government subsidizes the peasant who installs a handpump with 25 to 95 yuan per pump. Today, 500 million of the total 800 million peasants of China require water improvement. It is roughly estimated that by 1990 China will require a minimum of 400,000 deep-well handpumps and 32,000,000 shallow-well handpumps--if 8 percent of the 500 million peasants use deep-well pumps, and each pump supplies drinking water for 100 people, and 32 percent of the 500 million peasants use shallow-well handpumps, and each pump supplies drinking water for 5 people.

Manufacture of handpumps in China is scattered at present. A rough estimate shows that, throughout the country, there are several hundred plants producing handpumps of a wide variety. Most of them are county/commune-level plants with production varying from a few hundred to up to several thousand units per year. The standardization problems of the product need to be solved urgently. The future for development of handpumps in China, a developing country with a huge peasant population, is a vast one. We are going to carry out improvements on China's existing handpumps and work out standards for products. While carrying on and developing China's traditional products, we will study the advanced technology of foreign products and design handpumps of higher quality, thus contributing to the development of handpumps in developing countries and to technological cooperation.

TESTING OF HANDPUMPS IN CHINA

Establishment of the Handpump Testing Centre of Asia

According to Project INT/81/026 and the "Proposal for Laboratory and Field Testing of Drinking Water Supply Handpumps and Animal- and Human-Powered Irrigation Pumps in the People's Republic of China" signed by CAAMS, UNDP and World Bank in April, 1983, emphasis will be placed on the testing and development of human-powered water-lifting devices for small-plot irrigation and handpumps for drinking water available at depths of up to 50 metres. The objectives are as follows:

- (1) Improvement and extension of potable water supply in rural areas where groundwater is available at depths of 50 metres by means of handpumps;
- (2) Increased food production through small-plot irrigation by means of human- and animal-powered pumps in rain-fed areas with short one-to-three-month dry periods and in dry areas where groundwater is available one to five metres below the surface;
- (3) Establishment of the laboratory as a regional testing centre for handpumps and animal- and human-powered irrigation pumps, where governments and manufacturers can have their products tested and obtain technical assistance for product improvement;
- (4) Field and laboratory testing of selected pumps to verify performance under simulated and actual use;
- (5) Development of a guide for the selection of handpumps and components best suited to particular installations, locations and applications;
- (6) Publication of a manual on the installation, operation and maintenance of handpumps.

For this purpose, the Handpump Laboratory has been established in CAAMS. It was basically completed by the end of June 1984, after intense work which began on March 15.

The Handpump Laboratory is a four-storied building 12 metres high. The total floor area of the building is 340 m². On the ground floor is the water supply equipment, including a water tank, air compressor, etc. A head-simulating valve, which simulates the actual behaviour of a handpump working at depths from 20 to 50 metres, is installed on the first floor. On the second floor is the transmission system and service shop.

The test pumps are installed on the third floor where the console cabinets are also set up. The control of the tests and display and printing of the results are computer-based. Circulating water is applied for testing; the water is continuously stirred in order to maintain desired turbidity. In this laboratory, we can carry out tests for pump performance, endurance, rigidity, adaptability and ergonomics. Twelve handpumps can be tested simultaneously.

At present, the transmission, water circulating system, head-simulating valve and circuit have been installed. Once the computer and instruments from abroad are received, adjusted and installed, the laboratory will begin operation. We are glad to take the responsibility for conducting the handpump tests in accordance with Project INT/81/026. We are also ready to test handpumps from other countries.

Field Testing

To test handpumps in the laboratory and field is a part of the objectives of INT/81/026. There are 24 types, which include 300 units of domestic and foreign handpumps, to be tested. After consultations among the Ministry of

Machine Building Industry and the provinces and municipalities concerned, the field testing will be carried out in the city of Jincheng in Shanxi, Changsha County and Wangcheng County and the city of Changsha in Hunan.

The Handpump Field Testing Office, consisting of the office of the Patriotic Public Health Campaign, the Water Conservancy Bureau, the Agricultural Machinery Bureau, and the Epidemic Prevention Station, has been established in the city of Jincheng. Ninety units of six types of handpumps from abroad and sixty-three domestic pumps from eight plants will be tested in Jincheng. They are mainly deep-well pumps for drinking water supply. Seventy-six units of five types of handpumps from abroad and seventy-four China-made handpumps from thirteen local plants will be tested in Changsha. They are mainly shallow-well pumps for drinking water supply and irrigation. The counties and plants supplying handpumps for testing are shown in Table 1.

In order to facilitate the field-testing work, CAAMS, together with the Machinery Department and the Committees of the Patriotic Public Health Campaign of Hunan and Shanxi, conducted training courses from March 2 to 9, 1984, in the cities of Changsha and Jincheng. The trainees were personnel who oversee the testing pumps, water conservancy workers, and health workers from communes. More than 50 people were trained in Changsha, and 138 people trained in Jincheng.

Mr. L. Rosenhall, Regional Project Officer, INT/81/026; Mr. K. McLeod, INT/81/026 Consultant, World Bank; and Mr. Kyaw Myint Yap Choke Chong, United Nations Volunteer for the INT/81/026 Project, gave lectures at the training course and paid visits to the testing sites and handpump plants. Engineers from CAAMS, together with members of related research institutes, plants, and sanitation and anti-epidemic units, explained the origin and activities of the Project; gave lectures on the structure, installation, operation and service of the handpumps to be tested; gave instructions in methods of monitoring the handpumps under test and of data logging; and discussed the selection of wells.

Since March 1983, domestic test pumps have been installed for testing in succession. The behaviours of each and every pump under test was recorded and sent to the manufacturer to help each make some appropriate modifications. Close links between the testing workers and the manufacturers have been well-established.

China has produced shallow-well handpumps for a comparatively long period of time. The shallow-well pumps have been well-received by the peasants; however, the deep-well pumps have only recently been introduced, and the manufacturers are sparing no effort to develop them.

Type and Application of Well-Construction Devices

The utilization of groundwater for irrigation in China can be traced back for about 4,000 years. The construction of old wells varies with local conditions. Most of them are shallow wells built up with timber or wicker lining, or stone or brick masonries. At present, deep wells and motor-pumped wells are becoming increasingly popular.

Hebei, Shanxi, Shandong, Henan and Shaanxi provinces are the major areas of well irrigation in North China. More than 80 percent of the total motor-pumped wells in North China are found in these provinces.

In the past, most of the wells were dug manually. One of the widespread traditional well-digging devices, the so-called "caldron-type drill", is shown in Figure 11. Today, however, power-driven machines have been commonly used to make wells with diameters of more than a 0.5 metre (or with smaller diameters), but as deep as 300 to 400 metres.

Depending on the mode of operation, the drilling equipment can be divided into manually operated and power-driven types; or, in terms of the drilling mode, they can be divided into rotary and punching types.

Handpumps are usually mounted above the wells of large diameter and/or on the tubewell directly. The handpump wells are mostly dug by hand with simple digging tools. However, small-sized well-making machines are also used wherever conditions permit. In the Yunxiao County Farm Machinery Plant in Fujian, a special team has been formed to mount handpumps and clean up wells at users' requests. This team uses a ZS50A Model drilling machine produced by Zhenjiang Reduction Gear Plant. With a ZS50A drilling machine, one or two men can complete a handpumped well within one or two hours. The diameter can be 50 mm, 75 mm, and 100 mm. The maximum depth is 50 metres. A 3-hp gasoline engine is equipped for power.

China has used human- and animal-operated water-lifting devices since ancient times. As a developing country with a high peasant population, China does and will need handpumps for domestic water supply and small-plot irrigation in considerably large quantities now and in the future. We are willing to do our best to fulfill the task of INT/81/026: to make contributions towards the development of handpumps; to exchange technical information with other developing countries; and to work towards the achievement of the goals of the International Drinking Water Supply and Sanitation Decade.

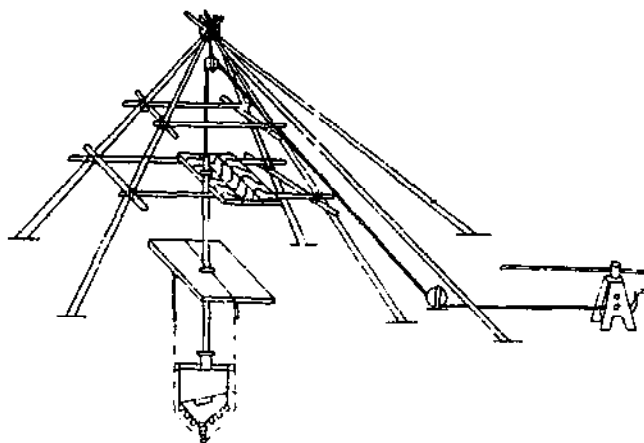


FIGURE 11 CALDRON-TYPE DRILL IN OPERATION

Table 1

No.	Place of Origin	Model	Pump for lab testing in		Pump for field testing in	
			Beijing (unit)	Changsha	Jingcheng	Changsha (unit)
1	Xinzheng Machinery Plant in Shanghai	SM-2 diaphragm pump	2	--	5	10
2	Yunxiao County Farm Machinery Plant in Fujian	SYB-80 handpump	2	--	10	10
3	Dayu County Farm Machinery Farm Machinery Plant in Jiangxi	SY-81 handpump	2	--	5	10
4	Changsha County Light Machinery Plant in Hunan	SYB-100 hand-press pump	2	--	5	18
5	Miyun County Farm Machinery Plant in Beijing	Deep-well pump	2	--	13	--
6	Tai'an Water pump Plant in Shandong	Deep-well pump	2	--	--	10
7	Gaoping County Farm Machinery Plant in Shanxi	Deep-well pump	2	--	15	--
8	Deep-well Pump Plant in Shanghai	Screw-rod deep-well pump	2	--	5	5
9	Pinghu County Farm Machinery in Zhejiang	Screw-rod deep-well pump	2	--	5	5
10	Water and electricity equipment Plant of Shandong	Diaphragm pump	--	2	--	1
11	Tong'an County Farm Machinery Plant in Fujian	MB-290 diaphragm pump	--	2	--	1
12	Zhenjiang Sprinkler Plant in Jiangsu	Jinshan-402B bike pump	--	2	--	1
13	Anyue County Farm Machinery Plant in Sichuan	1 1/2 SB Centrifugal pump	--	2	--	1
14	No. 1 Farm Machinery Plant of Suining County of Sichuan	Peijiang handpump	--	2	--	1
15	Dongfeng Farm Machinery of Jing County in Hebei	884210 animal-operated pump	--	2	--	1
			18	12	63	74
16	India	Mark II	2	--	30	--
17	Malawi	Maldev	2	--	20	10
18	Bangladesh	Tara	2	--	10	30
19	Zimbabwe	Blair	--	2	--	30
20	England	Consallen	2	--	10	--
21	Federal Republic of Germany	Preussag Turni	2	--	10	--
22	Federal republic of Germany	Preussag Kardis	2	--	10	--
23	Bangladesh	Rower	--	2	--	3
24	Bangladesh	Treadle	--	--	--	3
			12	4	90	76
		TOTAL	30	16	153	150

THE RESEARCH AND PRODUCTION OF MANUALLY OPERATED PUMPS
AND THEIR APPLICATION TO WATER SUPPLY IN FUJIAN

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First of all, let me take the opportunity to convey to the conference the congratulations of Fujian Machinery Bureau, Fujian Turbine-Pump Research Institute and Fujian Manually Operated Pump Works.

FOREWORD

Fujian, situated in the southeast of China, facing the Strait of Taiwan, with an area of about 121,700 km², a coastline of about 3,300 km and numerous islands, has a varied topography consisting of a mountainous region and hilly and flat lands. The population of the whole province is about 26,000,000. In the whole province, there are about 663 rivers, large and small. In the coastal area, the water in the earth's surface is short and the groundwater is rich. It has been explored and the groundwater deposit is up to 20 billion (US) m³.

The average annual rainfall of the province is up to 900-1,200 mm, and the evaporation capacity is up to 1,200 - 2,200 mm. In general, the rainfall (60 - 70 percent) is concentrated in the period from May to September. The rainfall in the rest of the year is infrequent.

Based on the general survey of 1980, only 12 percent of the population of 26,000,000 in the province have drinking water from the tap; 10.76 percent (about 3 million) from paddy field water, gully water and pond water; 13.27 percent from rivers, brooks and reservoirs; and the remainder from groundwater and mountain springs.

According to the general survey, there are now about 8 million people in Fujian whose drinking water is not up to the required standard of hygiene. The distribution of these people is as follows: 1,200,000 in the coastal area, 4,000,000 in the mountainous region, and 2,800,000 in the remaining area. There are also 3,150,000 people who are short of drinking water. The distribution of these people are as follows: 1,580,000 in the coastal area and the remainder in the other regions, dispersed over 158 communes in 23 counties (municipalities). Following the increase in income and living standards of the peasants (the result of the practice of the farm job responsibility system), solving the drinking water problems has been placed on an important agenda, along with establishing irrigation systems in the small fields. Hence, the research, development, production and application of manually operated pumps are widely welcomed and appreciated by the people over the towns and counties in our province.

THE STATE OF THE RESEARCH AND PRODUCTION OF
THE MANUALLY OPERATED PUMP IN FUJIAN

After the birth of new China, there was a lot of work done to solve the problem of drinking water supply in the rural area of Fujian. A great deal of investment and material resources has been provided for the effort (especially in utilization of water and improvement of water quality). A proper agency unit has been established to take charge of this work. Up to now, the effort has enabled more than three million people in Fujian to enjoy the sanitized water. Initially, manually operated pumps are installed in towns and counties to draw ground water. They are simple in structure, being basically piston-like hand-press pumps. Such pumps were pieced together from iron and bamboo pipes, and individually sold in the small county shops. Time between service periods is short, as the pumps are poor in quality. From the viewpoint of manpower conservation, it is not reasonable that so many manually operated handpumps operate in towns and counties without being studied and well-made. In order to meet the further needs of drinking water in the rural area, Fujian Turbine-Pump Research Institute was committed by Fujian Machinery Bureau in 1982 to study methods of improving water supply. Since that time, the agricultural machinery works owned by the counties have been appointed to accomplish the task. The goal is to manufacture manually operated pumps which are as small, simple and inexpensive. The following parameters of technique and economy must also be met:

- (1) The price of a pump must not be higher than the total price of a pair of buckets, a shoulder pole, a rope and a pail.
- (2) The level of design and manufacture of the manually operated pump must correspond to the economy, technique and culture of the district where the pumps are installed, so that the clients may use and repair them without any difficulty and the necessary parts can be replaced in the said district.
- (3) The pump must be durable and operational for no less than 500 hours.
- (4) After being idle for 24 hours, the pump must operate normally without the requirement of adding water.

At present, the manually operated shallow-well pumps for drinking water-- model 8SYB-80 and model 8SYB-90 of the Yun Xiao County Agricultural Machinery Works--are mass-sold in the towns and counties in and out of the province. Until now, 25,000 pumps have been sold. On September 17, 1983, pump model SYB-90 was sent by our nation and the experts of the United Nations to the laboratory of the British Consumers' Association in London for comparison tests. The performance results are as follows:

Discharge of water: 1.6-2 T/Hr.

Maximum suction head: 8 m.

Duration period for continuous operation: 500 Hr.

Greatest acting force: 10 kg.

While developing manually operated pumps for drawing water from shallow wells, we also studied and manufactured manually operated pumps for irrigating small fields. Fujian is rich in water resources from the earth's surface and ground, but these resources can only meet the irrigation requirements for a small portion of fields--far from solving the whole irrigation problem by natural flow. Tools for drawing water are required because of the differences existing between the field levels. Applying engines and electric pumps waste much energy and money and place a heavy burden on the peasants. For example, a 120-HP diesel engine would consume 216 litres of diesel oil for ten hours of operation a day and would cost over 2000 Yuan (RMB) a month. It was therefore decided that, because of the increasing costs of energy, the member nations of the United Nations must exchange ideas on manually drawing water at an international conference entitled "Workshop on Water-Lifting Devices and Water Management" held by FAO and UNDP in Fuzhou on November 3 - 9, 1981. It was pointed out in Item "3.2.2" of the summary report on the conference that in solving the problem of drawing water, our attention must turn to the fundamental needs of an impoverished society in the rural areas; furthermore, human- and animal-powered water-drawing tools must be fully investigated. Though such tools may eventually be replaced, manpower must be used for several in a number of certain cases.

We agree with the conclusions of the conference, especially the recommendation for developing countries rich in resources and manpower (e.g., China) to utilize manually operated pumps. Therefore, when we developed manually operated pumps for drawing water, we also developed suction pumps for irrigation. The technique and cost requirements for manually operated irrigation pumps are as follows:

- (1) The pump must be operated either manually or by pedal and must have an advantage over dragon-bone water lifts.
- (2) Its price must be lower than that of the dragon-bone water lift.
- (3) It must be lightweight and easy to operate, with a minimum acting force.
- (4) The replaceable parts must last for more than 500 hours.

At present, the manually operated pumps mass-produced by Fujian Tongan County Agricultural Machinery Works are substituted for the ancient-styled drawing water tools in rural areas, e.g., counterpoise, swing can, bamboo tube-water wheel and dragon-bone water lift, etc.

During the process of developing manually operated pumps, much attention has been paid to the specified criteria of the products. An enterprise standard called "Fujian Provincial Technique Conditions for Positive Displacement Pump" was therefore formulated as a quality, performance and acceptance specification test for the manually operated pumps in Fujian.

When developing the manually operated pumps, we became aware that both laboratory and field tests are key for ascertaining technical measurements on reliability and durability. Since 1982, three kinds of such test stages have been designed and built:

- (1) Test stage with a height of 10 m above the water's surface.
- (2) Test well with a depth of 10 m, adjustable in water level.
- (3) Laboratory test stage with height of 5 m, controlled both manually and electrically.

At the same time in the factories, test stages were built for duration tests under which continuous operation and shift records are required. Laboratory experiments are carried out to examine the parameters of the hydraulic performance given by the designer and the durability of the materials used. Field tests are performed to examine the durability of the manually operated pumps under several conditions in water of various qualities and use by numerous operators. The first batch of the products meeting the hydraulic performance standards will be dispatched to field trial sites following approval by the clients.

One additional point is that the development of the manually operated pumps still requires comprehensive international cooperation. With such cooperation, the technical level of manufacture can surely be raised. In March 1984, a field test training class for manually operated pumps was run by UNDP and the World Bank in the Hunan and Shanxi provinces. In the class, a Model 8SYB-90 manually operated shallow-well pump for drinking water supply and a Model 8MB-290 manually operated irrigation pump made in Fujian were installed for demonstration. In May of the same year, a project for making and testing manually operated rotary pumps was initiated by our province with the cooperation of American Cpydesdale Pump Lit. Co. These manually operated rotary pumps are a new type of positive displacement pump. The major features are as follows:

- (1) No valve is required in the inlet and outlet.
- (2) It is small and portable, the external dimensions being 10 x 8 x 6 inches.
- (3) It can be turned clockwise and counterclockwise and operated both manually and electrically.
- (4) It is available to carry both corrosive and viscous liquids.
- (5) The maximum discharge may be up to 50 US gal/m.

At present, such rotary pumps made by Fujian Machinery Works (with annual output in the tens of thousands) are to be distributed by the U.S. there and in Europe.

THE APPLICATION OF MANUALLY OPERATED PUMPS IN FUJIAN

Manually operated pumps in Fujian are simple in structure, durable in service, cheap enough for the peasants to buy and convenient for them to operate and repair. For years the manually operated pumps have been widely used in our province and now help peasants in rural areas improve their drinking water and save labour and time. The manually operated pumps are

therefore being quickly developed. Uses and application of the pump can be viewed in "The Video of Manually Operated Pumps Applied in Fujian", which may be summarized as follows:

- (1) Manually operated pumps installed on large wells: There are hundreds of thousands of large wells in Fujian. From ancient times, people have drawn water from wells with a bucket and flaxen rope. Water in the wells was therefore contaminated by the rot and filth from the rope and bucket. Adopting such pumps has greatly raised the level of drinking water quality and lessened the necessary labour inputs, a fact much appreciated by the people.
- (2) Pipe insertion for installation of manually operated pumps: In most Fujian towns and counties, rich ground water is available at depths of about 2-10 m. Water is obtained by inserting an electro-galvanized steel pipe into the earth; the end requires slight treatment and the outlet requires installation of a pumphead and supporting block. An insert-type well is thus formed. The location of the well may be set by the stove or door, or in the court of the building, as the users please. The advantages for this installation are as follows:
 - A. The wells occupy a small space and are flexible, expedient, and convenient for water use.
 - B. The quality of water from such insert-pipe wells is much better than from large wells.

The Fujian Tongan County Epidemic Prevention Station carried out tests on water from 20 wells similar in geography, geology and other characteristics and made seasonal comparisons of the water from 20 insert-pipe wells. The quality of water from the insert-pipe wells met the standards of hygiene for drinking water. The former 20 wells, however, were below standard. It was therefore proven that development of insert-pipe wells (instead of large wells) can help solve the problem of drinking water supply for mass populations. Hence, the insert-pipe wells have been recently developed in Fujian and produced in quantities up to the tens of thousands.

- (3) Manually operated pumps installed along rivers, brooks and ditches: In our province, towns have usually grown up beside rivers and villages along brooks and ditches; people have used these sources for drinking water supply for generations. As modern industry has developed, the water of the earth's surface is daily becoming more seriously polluted. Continuation of the old methods of drawing drinking water from rivers and rivulets threatens the health of the people. To solve this problem, manually operated pumps installed along the rivers, brooks and the ditches are now widely used in our province. The method requires insertion of a suction pipe into the bottom of the river, brook or ditch to about 1 - 2 m in depth. The end of the pipe is treated, and the outlet mounted with a manually operated pump. Having been filtered through the sand layer (the natural filter for the polluted water), the water drawn by the manually operated pump conforms perfectly to the hygienic standard

for drinking water. This method provides safe drinking water to the people living along the rivers, brooks and ditches. The manually operated pumps have also spread to the islands near the coast in our province.

- (4) Manually operated pumps for irrigation of scattered fields: Our province varies in topography, with many scattered fields of various levels. Under such conditions, use of electrical machinery would consume a large amount of energy. In comparison, applying flexible and expedient manually operated pumps which can be operated alternatively by hand or by pedal has solved the irrigation problem for small fields. Such pumps are also accepted and welcomed by the masses. In our province, one pump is generally owned by one to five families. Manually operated irrigation pumps treated for corrosion will now be used for drawing seawater in salterns on the coast, thereby saving much oil and electric energy as well as increasing the income of the saltworkers.

The development of manually operated pumps in Fujian is continuing on a large scale. Our aim is to develop a multifunctional manually operated pump, and, simultaneously, to continue studying and experimenting with the design, hydraulic features, human body engineering, component materials, processing and construction. We are going to strengthen our contacts and cooperation with other nations throughout the world and further develop the manually operated pump to correspond to the various states of our country. And surely, we are also striving for technical exchange among the developing countries so that more people throughout the world can benefit from these results and fulfill the global targets put forward by the United Nations--that all people enjoy safe drinking water and the well-being provided by the hygienic conditions.

ACTIVITIES OF "THE INTERNATIONAL DRINKING
WATER SUPPLY AND SANITATION DECADE" AND THE
APPLICATION OF HANDPUMPS IN CHINA

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It is my pleasure to congratulate the opening of the International Drinking Water Supply and Sanitation Decade and the Application of Handpumps Conference in China and to give my best wishes to all the experts involved. Please allow me to take this opportunity to give you a brief introduction to the activities of the International Drinking Water Supply and Sanitation Decade in China, as well as the present status of drinking water and the future program of rural drinking water improvement in China.

The Thirty-Fifth United Nations Congress held in 1980 decided that during 1981-1990, the activities of the International Drinking Water Supply and Sanitation Decade would be carried out. The global goal of this program is to guarantee "Safe Drinking Water and Sanitation for All" by 1990. The Chinese government actively supported and decided to join this program. In April 1981, the State Council issued the No. 61 Document and put forward some principal requirements on the program. The government at various levels has put great efforts on the "Decade" activities, which are regarded as one of the important aspects in improving people's daily life and spiritual civilization. It is greatly promoting the improvement of rural water supply. Until the end of 1983, 253 of the 289 cities in China had established central water supply systems. There have been 660 waterworks built recently. The total length of pipelines reaches 56,852 kilometres. The daily supply capacity is 35,380 million tons. The population access to tap water is as many as 77.293 million people accounting for 85.2 percent of the total urban population. The drinking water supply of the small counties has also been improved significantly and the accessibility rate of piped water reaches over 50 percent.

In rural areas, the work of water improvement is fully underway, and water qualities have steadily improved with the development of agricultural production and the Patriotic Health Campaign. In particular, since the Third Plenary Session of the Eleventh Central Committee of the Chinese Communist Party, a series of important reforms has been taken in the countryside and farmers' enthusiasm for agriculture production is higher than ever. The fruitful achievements due to the economic reform in rural areas resulted in an increase in farmers' incomes and living standards. All these are promoting the water improvement work.

According to incomplete statistical data, the population benefiting from water improvement has reached 350 million, accounting for 40 percent of the total rural population, of which 15 percent are supplied with piped water.

Quite a few counties have made faster progress than others, i.e., Tongxian and Daxing counties of Beijing Municipality, Jincheng County of Shanxi Province, Deqing and Jinhua County of Zhejiang Province, Donghai County of Jiangsu Province, Huanglong County of Shanxi Province, Jiayang and Chaoan Counties of Guangdong Province and Chong Ching County of Sichuan Province. The accessibility rate of piped water in these areas is over 50 percent. Approximately 150,000 persons in Chaoan County of Guangdong Province benefited from water improvement, accounting for 90 percent of the population. The progress had been made rapidly. The water improvement has been conducted on a large scale in 40 counties of Hebei Province. The water sources are well-protected, and the water quality meets the requirements of the National Standards for Drinking Water Quality. Safe water is available for 80 percent of the population in this area. Of the rural population in Gaocheng County of Hebei Province, 95 percent are supplied with piped water.

The incidence of endemic diseases has been significantly decreased. Much progress in water defluoridation has been made in northern China, and the beneficiaries account for more than two million people. After the improvement of water qualities, the fluorosis patients, with both serious and mild cases, have become much better. The occurrences of new cases have been controlled. For instance, in the two villages--Erzijing and Tizijing in Qianan County of Jilin Province--signs and symptoms of fluorosis in 87.3 percent of these cases have been improved upon or fully overcome. This fact indicated that water improvement plays a very important role in raising the living standard, reducing the incidence of disease, promoting the health status and increasing agriculture production.

Based on the economic conditions at various periods, water improvement in rural areas has gradually developed from low to high levels. In the 1950s to 1960s, the major efforts were focused on the mobilization of the masses to improve the present available wells, draw spring water from mountains to villages and filtrate surface water. In the 1970s, stress was put on the use of wells with handpumps and, where possible, simple-styled piped water supply systems and community water supply stations. In the 1980s, our efforts are directed to further improving simple-styled piped water supply systems called rural running water to bring water to the households. After a survey of the types of water supply in rural areas, handpumps/wells, community water supply stations and various types of rural running water supply systems are considered to be the better forms of water supply. In order to provide safe water, more rural running water systems will be set up in the countryside.

Although the work on water supply is rapidly developing, it still cannot meet the demands of consumers, because China is a developing country with a relatively poor economy and a huge population. At present, various problems in drinking water for 500 million farmers need to be solved. Among them, problems for 300 million people are quite urgent. Up to now, about 42 million people are short of drinking water. Over 45 million people distributed in 47,000 villages in 574 counties in 26 provinces, municipalities and autonomous regions drink water with high fluoride content. About 63 million people drink bitter salty water, and 150 million drink surface water contaminated in various extents by domestic sewages and pesticides. Thus, the future task of water improvement in the countryside is still arduous.

In the last three years, much work in Decade activities has been carried out, accelerating the water improvement in rural areas.

Now, I would like to present a brief account of our experiences in water improvement.

1. Greater understanding and a strengthened lead function: Improving water quality is the desire of most people, particularly farmers. The Government at various levels has taken Decade activities as an important part of improving people's daily life, constructing the material and spiritual civilization and accomplishing the four modernizations. The State Council decided to establish a National Water Improvement Action Committee responsible for Decade activities, based on the Central Patriotic Health Campaign Committee. The new committee includes representatives from related ministries and organizations, such as the Public Health, Water Conservancy, Urban and Rural Husbandry and Fishery, Planning, Finance, Trade, Chemical Industry and Material Ministries. It is clearly indicated that the stress of Decade activities is placed on water improvement in the countryside. Governments at various levels must put this work into their long-term program of national economic development and give more financial support to water improvement. According to the document issued by the State Council, the Patriotic Health Campaign Committees of various provinces, municipalities and autonomous regions regard the Decade activities as an important and long-term task in their agenda. They have worked out a Decade program for water improvement in ten years and also an annual plan to carry out water improvement in a planned way. Some of the provinces and counties have established a lead organization and set up an office responsible for water improvement to ensure that the work is conducted smoothly. The leading organization consists of members from provincial or county bureaus of Planning, Finance, Urban and Rural Construction and Environmental Protection, Water Conservancy, Public Health, Agriculture, Animal Husbandry and Fishery, Material, Economy and Trade, Chemical Industry and Light Industry
2. Investigation of water sources and water quality: Improving drinking water is a kind of massive social and technical job. It is vital to make good investigations and keep abreast of current background data on water sources and water quality. The Central Patriotic Health Campaign Committee and the Ministry of Public Health have worked out a nationwide programme for surveying drinking water sources and water quality. The Institute of Health of the China NCPM was entrusted to hold a workshop on water sources and water quality surveys in Nanking last March. Detailed plans for the survey have been made during the workshop. All the provinces, municipalities and autonomous regions have carried out massive surveys on water sources and water quality according to the nationwide unified requirement and using unified methods and steps. From the survey, we accurately obtained data on the distribution of local water sources, quantity, types of drinking water, distribution of salty water, high-fluoride water, polluted underground and surface water, and numbers of households and persons who drank these kinds of water; we also learned of the distribution and occurrences of waterborne diseases. These data provide scientific bases for water improvement. For example, in Jinghua county of Zhejiang Province, where a survey was carried out earlier, the

officials obtained nearly ten thousand figures. After grasping the situation of water sources, quantity and quality in the whole country, they worked out a practicable programme for water improvement. Over four years of efforts, 519 water works have been built, which have enabled 56.14 percent of the entire population to use piped water and opened up new prospects for the improvement of drinking water in the countryside.

3. Works run by the local people and subsidized by government: Our policy is to rely mainly on our own efforts, while actively seeking external assistance through subsidies. The domestic funds are mainly raised from three sources, i.e., investments from government, collection units and individual people. The state provides more support to the areas with economic difficulty or severely endemic fluorosis. For the areas with less economic difficulty, minimum funds will be supplied by the state, and the rest raised from collective and private sources. For areas with a better economy, the funds are mainly raised from collection and private sources. Since our country is a developing country, we still have some economic problems. At present, the government is only able to provide limited funds for water improvement, which is far from adequate. Therefore, it is necessary for us to seek external assistance. Recently, we have come to an agreement with the World Bank for non-interest loans for rural water improvement. Up to now, the loans for the rural water improvement have been distributed to Beijing, Liaoning, Shanxi, Sichuan, and Zhejiang provinces and municipality. We plan to make an evaluation on 24 August of this year (1984). The collaborative project of water pump tests is going on smoothly under the joint efforts of the Chinese government and the World Bank. In the future, we will steadily increase cooperation with international organizations and foreign countries in this field.
4. Stress on miscellaneous forms and practical results: Because of different conditions in local areas, we have taken different practical and effective measures in improving the water supply system. Since our country has vast territory with complicated geographical conditions; and the water supply forms, population sizes and economic situations are quite different from area to area, a method that is good in a place may not suit other places.

In China, people in many areas have summed up their own experiences through practice and found the most effective measure to solve their problems. For example, tap water supply from the pressure tank was invented by the waterworks company in Daxin County, Beijing Municipality. The tank is easy to control, easy to install and low in cost. It has been popularized as a new type of water supply system all over the country. The coupled-pond type waterworks and water tank are the other types of water supply systems suitable for the water net area in southern parts of China, as well as coastal areas where there is a short supply of fresh water.

In the northern parts of China, depending on the different geographical situations and available water sources, people take measures such as drawing water from springs or rivers, storing rain water in pits or digging wells.

In solving the water supply problems, our principles are to give priority to those problems which are easy to solve and need less investment, as well as problems in areas with great population density.

5. Attention to the personnel training and strengthening of management:

In order to manage the waterworks in the countryside, it is necessary to build up a group of technicians and managers. In recent years, the central and local governments have paid a great deal of attention to knowledge investment and talent development. The Central Patriotic Health Campaign Committee entrusted the Beijing Medical College and the Institute of Health of the China NCPM to run training courses on water supply hygiene, workshops on water sources and water quality surveys.

The World Health Organization, World Bank and Bureau of Technical Cooperation of the Federal Republic of Germany have convened a series of training courses on management, engineering and accounting in Dalian, Guangzhou and Shanghai. Many people have gained advanced knowledge from these courses and become qualified teachers in water supply. A large number of engineers, technicians, and managers were also trained. Many training courses were held for waterworks operation and maintenance on the county levels to assure the improvement of drinking water supply continues successfully.

In order to assure the normal operation of the waterworks, the management was strengthened at all levels in China. Many waterworks have carried out various methods of management reform, such as contract systems. Since the management reform, the beneficial effects of water supply improvement were brought into play.

To improve the supply and quality of drinking water is not only an important measure for improving the urban and rural environment and the people's living and health standards, but also our international obligation to join the activities of "the International Drinking Water Supply and Sanitation Decade" launched by the U.N. for the goal of safe water for all by the year 2000. At present, the drinking water supply of 500 million people still needs to be improved, 300 million of whom are in urgent need. Since 1981, our government has worked out detailed plans and goals, i.e. two years for preparation, three years for pilot studies in selected areas and five years for popularization. In ten years or more, most of the rural areas in China will have access to drinking water which meets the national hygienic requirements. This is the second year for the pilot studies in certain areas. In 1983, 25 million people have been supplied with improved drinking water. It is expected that this figure will be significantly increased this year. Before 1985, priority will be given to improving drinking water in the coastal areas, high-fluoride areas, areas with salty and bitter water and regions short of water. Plans are scheduled to improve drinking water for 100 million people. From 1986 to 1990, along with the further development of the national economy, the problem of drinking water for 50 to 60 million people will be solved each year. By the end of that period, most of the rural population will be provided with safe drinking water. In urban areas, the main task is to protect water sources, increase water quantity, expand the water pipe net, increase the accessibility rate of piped water, improve purification and disinfection facilities, strengthen water quality monitoring and ensure safe drinking water supply.

Our task of improving rural drinking water is very arduous, accounting for one-fifth to one-fourth of the total work of the international Drinking Water Decade. On one hand, we must work hard, improve organization, strengthen leadership, develop professional groups, train administrative personnel, spread and apply new technology, new techniques and new materials and adopt various methods in line with local conditions to open up new prospects in drinking water improvement. On the other side, we sincerely hope that international organizations and friendly countries will kindly offer us assistance economically, materially and technically. No doubt, such cooperation will play very important parts in achieving the goal of "the International Drinking Water Supply and Sanitation Decade" to provide safe water for all by 2000.

I hope the meeting will be successful and all our guests will have an enjoyable time in China.

ON-THE-SPOT TESTING OF HANDPUMPS IN JINCHENG CITY

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China

The city of Jincheng lies at the south end of the Taihang Mountain Range which is typical of inland mountain areas, with 30 small towns and 1,358 natural villages. It has a population of 603,834 people, 508,059 of whom work in agricultural production.

The drinking water conditions have greatly improved since liberation (1949). The speed with which tap-water sources have been developed has been especially remarkable in recent years, due to the efforts of the Patriotic Health Campaign. The number of local people who drink tap water has thus far risen to more than 50 percent of the city's total population. Difficulties, however, still remain when we try to supply tap water to those remote mountain areas which lack either water sources or electricity supplies.

In April 1983, the Chinese Government signed, with the United Nations Development Programme (UNDP/World Bank (WB)), a project agreement for "On-Site Testing of Handpumps" in our city, thereby affording us a chance to solve the drinking water problem. Because of the firm support of the Central Patriotic Health Campaign Committee, the Agricultural Machinery Research Institute of China and other leading departments; the guidance of Mr. Rosenhall, the official in charge of the East Asian-Pacific Affairs for the Handpumps Project, World Bank; Mr. Mcleod, Consultant, World Bank; and Mr. Jiaomin, Monitoring Engineer, World Bank; and the common efforts of our own people, some accomplishments have been made through the testing of handpumps since efforts began one year ago. Of the 153 pumps planned for installation, we have received 42, 27.4 percent of those planned; 31 of these pumps have been installed. Furthermore, 20 pumps are being monitored, 64.5 percent of those installed. As brief as the testing period is, the program has begun to play an active part in solving the drinking water problem for nearly ten thousand people in our city. The people say that the use of handpumps is safe as well as sanitary, and is convenient to both the old and the young. We think it is significant that we are conducting such a handpump test in an effort to solve the drinking water problem of developing countries.

ESTABLISHMENT OF ORGANIZATIONS

In August 1983, when we accepted the handpumps test project, the municipal government placed it on the agenda under the specific direction of a deputy mayor--an act signifying its importance. To deal with the daily routine, the Spot Test Office was formed with its seven members coming from the city's Water Conservancy Bureau, the Office of the Patriotic Health Campaign, the Agricultural Machinery Company and the city's Epidemic Prevention Station. A specific person was chosen for each village (or town)

involved in the project. As a result, some person at each level was designated to administer the tests.

SELECTION OF SPOTS FOR WELLS

Due to complicated geographical conditions, the underground water resources are distributed quite unevenly, and methods used by the people to obtain water are quite different. In order to suit local conditions and to make the best use of the available handpump devices, we organized about a hundred persons as water conservancy workers, agricultural machinery workers and epidemic prevention doctors to make investigations, village by village and well by well, of geological conditions, water resources and quality, well types and depths, methods of obtaining water, the number of the families supplied with water, sanitary conditions, etc. After investigation, we discovered that, in the area of the whole city, there are 373 wells in 224 natural villages suitable for the installation of handpumps. Based on the result of the investigations and conditions--traffic, sanitation, economies, etc.--of 10 towns and 81 villages, 153 wells were finally chosen as testing spots, 16 of which were high-depth, 106 middle-depth, and 31 low-depth.

WORKER TRAINING

Factories in five countries abroad and eight factories at home are involved in the manufacture of handpumps to be used in the test. There are various models of pumps with different characteristics being manufactured in an effort to make the workers familiar with a number of pumps and to enable them to achieve a better mastery of the techniques used in the installation, use and maintenance of the pumps. In early March 1984, some agricultural machinery workers, water conservancy workers, epidemic prevention doctors and handpump operators from all the towns and villages were trained for a short period by UNDP/World Bank with our assistance. In the course of the training, Mr. Rosenhall, the officer in charge of the East Asian and Pacific Affairs for the Handpumps Project and Mr. McLeod, Handpumps Project Consultant, gave elaborate instructions on the properties of the pumps and the requirements for installation and monitoring. Some technical personnel from the Chinese Academy of Agricultural Mechanization Sciences and from various handpump manufacturing plants in China provided guidance in techniques. Thus, after this training and examination, 145 trainees could understand the working principles and functions of the pumps, having learned how to install, operate, monitor and maintain them.

INSTALLATION AND MONITORING

In March 1983, as soon as the first set of pumps made in China arrived, we began installing them. Initially, the water quality was chemically examined by the Municipal Epidemic Prevention Station, and well terraces were constructed according to the drawings in every test village. Mr. Jiaomin and other technical personnel from the manufacturing plants were on the sites with the workers to help administer the tests and to give some installation directions. Monitoring began upon installation. Certain persons were assigned to run the pumps, monitor them at least once a week, and keep daily

records. According to the records of the past four months of tests, the 20 handpumps made in Hunan, Fujian and Jiangxi are high-quality and work very well, with the output meeting initial designations. They are suitable for the local uses.

LESSONS FROM EXPERIENCES WITH THE TESTS

We have learned the following from our experiences with the handpump tests.

Only when the masses are fully aware of the practical value and international significance of this "On-the-Spot Handpump Test" are they really willing to accept this testing task.

The people of our city were very pleased when they learned that this handpump test, conducted with UNDP and the World Bank, would take place here. They consider the project to be aid and support from the UN, and they believe that it is helpful and significant to have increasing international contacts and to develop friendly relations with other countries. The people have realized that the installment and use of these small-sized handpumps have profound significance. Not only can they solve the drinking water shortage problem, but also the sanitation problem of our city. As a matter of fact, the leadership of every town and village is devoting much attention to this project, working out plans or coming to the municipal government to ask to be involved with this project. Many local people are taking an active part in the installation and testing of handpumps, enthusiastically offering useful information, doing volunteer services, and providing all kinds of materials.

It is only by carrying out the system of personal responsibility that the work efficiency can be raised and the test quality can be assured. During the installation and testing of handpumps, we established the system of personal responsibility at each level. The duties of the municipal officials of the test include assisting the monitoring engineer with spot monitoring and recording, training the workers, establishing technical data, making regular investigations, organizing transportation, installing and maintaining the pumps, collecting opinions and suggestions of the masses and conveying them to the manufacturing plants for further improvements. The conservation workers in the villages and towns, the agricultural machinery workers and the epidemic prevention doctors make investigations of the local water resources, install pumps, maintain machines, improve sanitation conditions, etc. The duties of the pump operators from the testing towns and villages include looking after the well-pump apparatus, keeping monitoring records, filling out reporting forms regularly, seeking out public opinion and providing on-the-spot data. We connect the system of personal responsibility with economic benefits by carrying out a system of rewards and penalties.

It is only through aid and close coordination that the test project can continue successfully. Many departments have been involved in the testing; however, the program needs cooperation from and close coordination with persons from all walks of life. During the installations and tests, some concerned organizations of the UN provided us with machinery and tools, as well as with technique instructions and funds. Mr. Jiaomin, Monitoring Engineer, worked over ten hours a day and often appeared on-site to give

instructions, acts which were highly praised by the people. Technicians chosen from Shanghai, the Xinzheng Machinery Factory and the Zhejiang Pinghu Agricultural Machinery Factory came to our city to help with installation and maintenance. Some concerned departments and factories have done their best to take part in this project. We take this opportunity to express our heartfelt gratitude to the foreign friends and the Chinese technical personnel concerning what they have done for the test.

CONCLUSIONS

Although we have obtained some achievements in the tests, we know very well that compared with what UNDP/World Bank and our authorities want us to do, we still have a long way to go. Much more careful attention must be paid to the project. We look forward to receiving those handpumps which have not yet reached our hands. We hope that we can obtain both those pumps from abroad and another 21 pumps from Chinese manufacturers as soon as possible. We expect that all the involved manufacturers will be able to provide the spare parts as well. We also look forward to your continuous aid and assistance in coordinating activities. Let us join forces to do a much better job, to win still greater victories, and to overcome all the difficulties so that we can do our part in the "International Drinking Water Supply and Sanitation Decade".

SECTION 3

PROGRAMS IN SELECT DEVELOPING COUNTRIES

THE RURAL DRINKING WATER SUPPLY PROGRAMME IN
INDIA AND THE DEVELOPMENT OF A
DEPENDABLE DEEP-WELL HANDPUMP

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INTRODUCTION

The U.N. Conference of Human Settlements (HABITAT) held in 1976 recommended that safe water supply and hygienic waste disposal should receive priority from governments and international agencies in order to achieve the target of serving all the population by 1990. These laudable objectives were approved in the U.N. Water Conference held at Mar-dei-Plata in March 1977, and the decision was made that 1981-90 would be observed as the "International Drinking Water Supply and Sanitation Decade". These recommendations were later endorsed by the 31st U.N. General Assembly, which met in late 1977. India also signed the resolution seeking to achieve the targets by 1990, namely provision of a minimum level of service and access to safe water supply and sanitation for the people of the country. Accordingly, the Decade Programme in India was launched on April 1, 1981.

At the beginning of the Decade in India, in April 1981, about 77 percent of the urban population and 31 percent of the rural population had been provided with protected drinking water supply facilities. The Government of India has fixed a target to cover 100 percent of the population with protected water supply, both in urban and rural sectors, by March 1991. Meeting this target is expected to benefit new populations of 71.7 million persons in urban areas and about 446 million persons in rural areas.

PROGRAMME FOR DRINKING WATER SUPPLY

The provision of drinking water supply to villages has been given high priority. In order to identify the villages which needed immediate attention, a country-wide survey was conducted in the early 1970s through the initiative of the respective State Governments/Union Territory Administrations. The criteria for identification of such villages prescribed by the Government of India were as follows:

Villages where no water source existed within a distance of 1.6 kilometres or where water was available at a depth of more than 15 metres (in hilly areas, villages where water sources were available at an elevation difference of more than 100 metres from the habitation);

OR

Villages where the water sources had excessive amounts of salt, iron, fluorides and other toxic elements hazardous to health;

OR

Villages which were exposed to the risk of waterborne diseases, such as cholera, guinea worms, etc.

These villages have been termed as "Problem Villages". Out of about 576,000 villages, about 446,000 villages had some sort of drinking water supply problem in March 1983. During 1983-84, 50,138 villages were provided with problem drinking water. About 42,000 problem villages are expected to be covered during 1984-85.

INDIA MARK II HANDPUMP

History

Supplying safe drinking water to all villages of India is a major national task. The most important contribution made by the Government of India to the rural community, especially the problem villages, in support of the drinking water supply programme, is the DEPENDABLE, TROUBLE-FREE, DEEP-WELL HANDPUMP. The critical aspect is ensuring a durable trouble-free service and easy-to-repair handpump--the most vulnerable part of the maintenance system.

For many years, all State Governments have been drilling borewells and fitting them with cast-iron handpumps of traditional design. These pumps could not withstand daily use by several villagers. There were frequent breakdowns, ranging as high as 80 percent at any one time. The following were the major disadvantages in the cast-iron pumps.

The pump design involved many linkages which increased breakdown rates and the cost of spare parts. Certain spare parts and the body of the pump were made of cast iron and could not be easily reconditioned. The pumps were very heavy and prone to crack while in transit. The flange-to-flange bottom arrangement did not serve with rigidity over a period of time. The pipes were jointed directly to the body through a nipple and a reducer, and this arrangement was not providing prolonged service. When the threads in the body wore out, the body ceased to function. When the spout was damaged, repairs involved drilling and tapping. The handle was not sturdy, which lessened the mechanical advantage. Replacements were frequently made. In these traditional pumps, the components were not well-defined; therefore, there was no interchangeability of components. Because of low mechanical advantage and lighter construction, great effort was required for operation of the pump.

Development

In 1976, Richardson & Cruddas (1972) Ltd., (A Government of India Undertaking), in close cooperation with UNICEF and MERADO (A Government of India Search Unit), developed a fabricated handpump for deep-well purposes, after extensive research in various parts and field trials. Extensive field trials were carried out during the development of an acceptable cylinder.

What emerged was a top-quality standard pump which is today universally known as INDIA MARK II DEEP-WELL HANDPUMP (Figure 1). Today it is one of the most proven and cost-effective deep-well handpumps in the world.

After the field trials of 1,000 Mark II Pumps during 1977-78, it was very clear that the pump was highly reliable and easy to operate and maintain. The frequency of breakdown was less than 10 percent as compared to over 80 percent in traditional pumps. The pump body is fabricated from steel plates--this means a lighter body with high-strength properties as compared to a cast-iron body. The pumphead is hot-dip galvanised to make the body rust-free for years. The mechanical advantage is increased to 8:1, and the use of a heavy-weight handle (instead of a steel pipe) makes the operation very easy. Even children of 6 years-of-age are able to operate this pump with ease. The weight of the handle compensates for the weight of the eight connecting rods (24 metres in length). This considerably reduces the effort required for operation. The pump has only one pivot, thereby reducing the number of spare parts required for servicing. The maintenance cost of the pump comes to below 40 U.S. Dollars per annum as opposed to 100 U.S. Dollars for the traditional pump. The base is firmly grouted in cement concrete which provides rigidity.

Standardisation

The Central Public Health and Environmental Engineering Organisation (CPHEEO), the technical wing of the Ministry of Works and Housing, Government of India, took the initiative in 1977 to formulate Indian Standards for the Mark II Deep-well Handpump with the objective of standardizing the pump in India. Indian Standard Institution (ISI) brought out the specification in 1979. The specification gave detailed designs of components, schemes of inspection, samplings and criteria for acceptance of the pump. This standard is being reviewed every year with changes incorporated wherever necessary to improve the performance of the pump. The ISI specification, viz IS.9301-1979, was revised in 1982 and again is undergoing revision. The design is not patented by any firm; therefore, any organisation can manufacture these quality pumps. As the pump is well-defined through drawings of all parts and standardisation, the purchaser knows very well what is being purchased; inspection of the pump also has become easier. All the State Governments in India have accepted this pump for their programmes, and India now has one India Mark II Deep-well Handpump for all of their programmes. Over 440,000 pumps have already been installed in India, and this figure is likely to reach 800,000 by 1990, including old model pumps being replaced under the rejuvenation scheme. In order to maintain the quality of pumps, independent agencies are rigidly inspecting the pumps at the manufacturers' works before dispatch. On the initiative of CPHEEO, the Indian Standards Institution is now preparing a standard for installation and maintenance of this pump.

Further Development

India Mark II Handpumps can be modified for shallow-well applications as well as extra deep-well applications. The development by Richardson & Cruddas in this particular field is noteworthy. The pump has been modified by R & C for extra deep-well purposes to draw water from 100 metres. These pumps have been supplied to meet the conditions in the Sokoto State of Nigeria. These are perhaps the pumps with the deepest application in the world today.

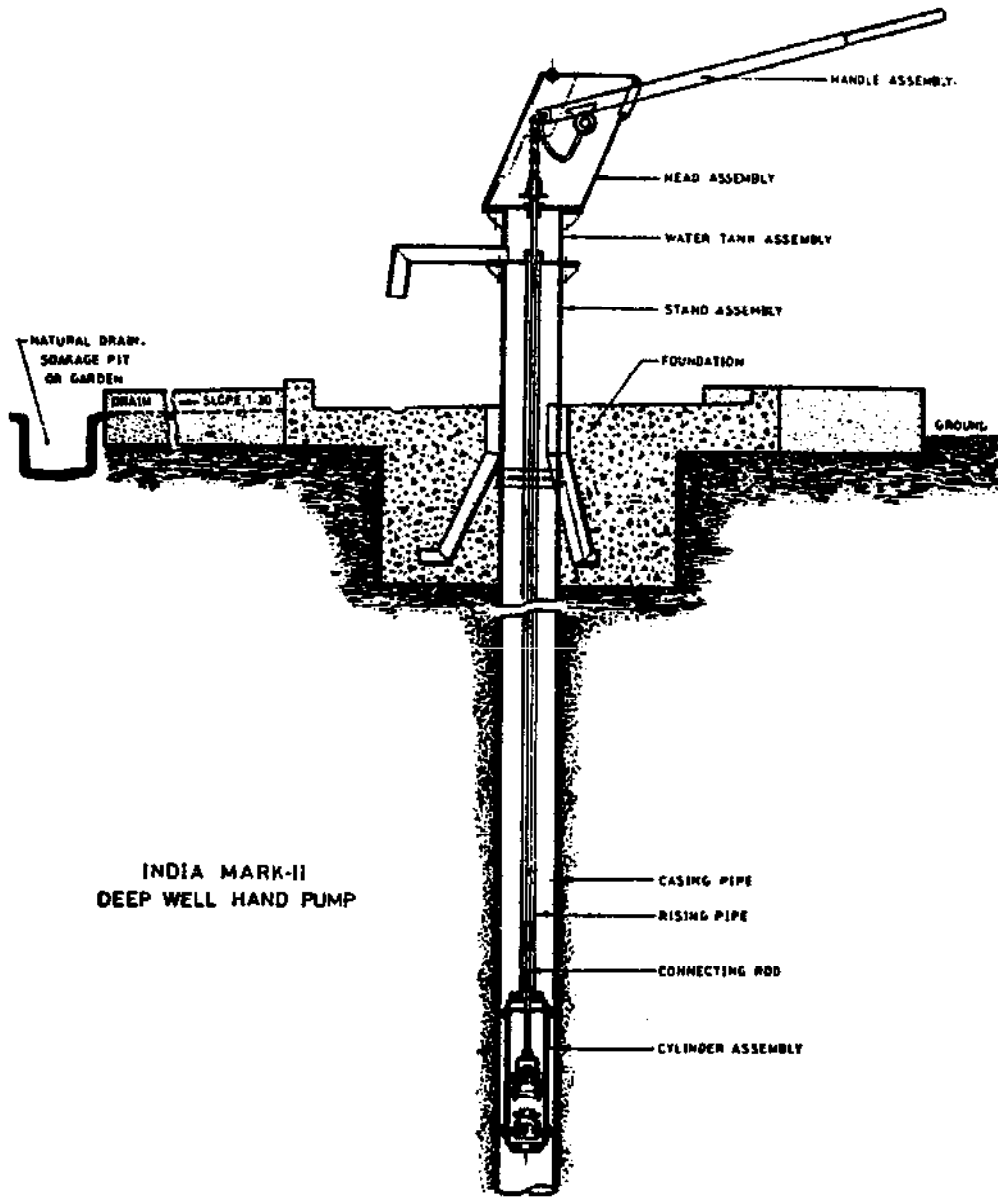


FIGURE 1

Shallow-well application has been well-received for drawing water from depths of 8 to 10 metres.

Further development work on this pump, in close cooperation with UNICEF and the World Bank, is taking place in Tamil Nadu, and various concepts are being tested in field trials. The objectives of further development work is to make this pump freely and truly a village-level operation and maintenance (VLOM) pump.

Special Tools

Special tools have been developed by Richardson & Cruddas (1972) Ltd. for installation and maintenance of India Mark II Pumps. This is a revolutionary development in that these tools make the installation and maintenance of the pump much simpler. No crane/hoist is required for installation of this pump. The pump for a 30-metre depth can be installed in just an hour with the help of three workers.

Quality Control

The fabricated handpump is a simple design requiring very accurate construction. The pump is subjected to an average of nearly 14 million strokes per year. It is therefore necessary and essential that the entire process from raw material supply and production of parts and sub-assemblies to final assembly is subjected to continual quality control preceded by quality assurance. As the handpump forms a very important part of rural/suburban water supply schemes, the purchasing agency must make sure that the manufacturer has strict 'internal quality control' systems covering the following check points:

- (a) Check of incoming parts;
- (b) Stage control check of components and sub-assemblies, including welding;
- (c) Sub-assembly clearance for surface treatment;
- (d) Sub-assembly clearance after surface treatments but before assembly;
- (e) In-line assembly inspection and testing.

In addition, the purchaser must ascertain the following availabilities at the manufacturer's premises:

- (a) Jigs and fixtures for locating the following assemblies:

Conversion head--guide bushing in relation to flange; flange, side plates, and back plates in relation to each other; left and right bushings with reference to guide bushing; handle window frame; front, bottom and side plates.

Water tank--Pipe coupler on the water tank bottom flange; spout pipe, bottom flange, tank pipe and top flange in relation to each other; gusset-locating fixture.

Handle assembly--Square bar, bearing housing and roller-chain guide; support plates.

Stand assembly--Flange in relation to stand pipe; collar and legs in relation to stand pipe and flange gussets.

Chain assembly - Location of roller chain and chain coupler in relation to each other.

- (b) All necessary slip gauges, ring and plug gauges, micrometer, elcometer, shore hardness tester, etc. (basic needs).

The workmanship and finish should be checked with particular emphasis on welding, mating of flanges, minimum distortion, required clearances, thickness and quality of galvanising, lineability, interchangeability, etc.

The manufacturer must also have a well-defined internal inspection procedure which should be verifiable with the help of records, formats, forms showing accepted and rejected parts and disposal of rejected parts, test certificates for physical and chemical properties, etc.

Finally, in addition to the quality control exercised by the manufacturer, inspection by the purchaser is necessary to ensure that the goods comply with the contract specification, that the manufacturing processes have been properly carried out and that the goods are properly packed for dispatch. The better the control exercised by the firm, the less stringent the need be for inspection instituted by the purchaser.

The whole exercise of quality control and inspection by the purchaser should be viewed with the ultimate aim of receiving defect-free, easily installed handpumps to provide a continuous supply of drinking water to the people in the remote and inaccessible problem villages, where the problem of maintenance should be minimal.

THE MAINTENANCE SYSTEM

It is not enough for the technology of the pump to be designed well; equally important for the efficient working of a handpump is the installation and maintenance system. The operational performance of the handpump forms the basis for community acceptance of the programme as a whole. The effectiveness of the maintenance system in turn directly affects the life and performance of the handpump and influences operational maintenance costs.

Continuous usage of the pump subjects it to wear and tear. There is also a correlation between the quality of platform construction/materials used and the frequency of breakdowns. It is therefore essential that members of the maintenance system carry out the following responsibilities:

- (a) Obtain prompt information about failure of pumps with the least possible communication gap;
- (b) Keep the surrounding platform clean and ensure the proper usage of the pump;
- (c) Regularly apply grease on the chain and tighten the bolts and nuts;
- (d) Examine the above-ground mechanism every month and carry out repairs as necessary;
- (e) Undertake repairs of underground mechanism/major repairs of above-ground parts, within reasonable time, on receipt of "Failure Reports".

The above points are effectively achieved in India by the adoption of what is generally known as the "Three-tier Maintenance System". The structure of this system provides for

- One village handpump caretaker for every pump;
- One 'block' level mechanic for no more than 50 pumps;
- One district-level mobile maintenance team covering 500 installations.

The functions of the above tiers are as follows:

The village caretaker is responsible for keeping the handpump site dry and clean; for servicing the handpumps once a week, including tightening the bolts and nuts and applying grease on chain assembly; for channeling excess water into a garden or soak pit; for explaining and demonstrating the correct method of handpump operation to users of the pump; and for reporting promptly all handpump breakdowns to the District Engineer. He reports by mailing pre-printed, prestamped and pre-addressed "Handpump Failure" Postcards on which he only makes a tick mark against the appropriate space mentioning the specific type of failure. The Caretaker is selected from educated volunteers in the village. Caretakers are very important persons in the Maintenance System, because if they conscientiously and regularly perform their duties and responsibilities, they significantly contribute towards providing people with a continuous source of safe, clean, drinking water.

A "Block" Level Mechanic with tools and a bicycle visits on a regular basis, usually once a month, all the handpumps in his jurisdiction. He can carry out minor repairs that arise in the pumphead, but cannot deal with the problems of the below-ground mechanisms. He informs the District Engineer whenever a major repair is anticipated or needed.

The District-Level Mobile Team, a key element in the modernized Handpump Maintenance System, consists of four men (a Junior Engineer, a Senior Mechanic, a Mechanic-cum-Driver, and a Fitter), equipped with a diesel pick-up truck and a small workshop at the District Office. Each team is expected to carry out both preventive and corrective maintenance of both above-ground and below-ground mechanisms.

The above system is continuously reviewed and updated. The cost of maintenance is met by the State Governments.

COST FACTORS

- (a) A complete India Mark II Deep-well Handpump including cylinder and connecting rod of 30 metres, costs 150 U.S. Dollars.
- (b) The estimated annual recurring cost per pump is about 40 U.S. Dollars, which includes spare parts and cash costs of the mobile team. This is nearly 40 percent of the annual maintenance cost of the other types of pumps, such as cast-iron double guide, Jaina, etc.

CONCLUSION

No doubt the development of the India Mark II Deep-well Handpump was a big stride in providing safe and assured water for the rural population as well as fringe portions of the urban population. The search for a bigger stride continues. The World Bank has embarked in India on a project to further improve the below-ground mechanism of the India Mark II Deep-well Handpump, involving UNICEF, RICHARDSON & CRUDDAS, WAVIN INDIA, and the Government of the Tamil Nadu State. In the present form of the pump, the riser main is lifted along with the cylinder body and the connecting rod, to carry out any repair required in the plunger assembly and check valve assembly of the cylinder. At present, only the replacement of the cupwasher, which accounts for 75 percent of the repairs in the cylinder components, calls for the removal of all the above-mentioned parts. The object of the new experiment is to find a way of retaining the cylinder body and rising main, but lifting the connecting rods with the lower and upper valve assemblies only. This will greatly reduce the cost of maintenance and improve the mobility of maintenance teams, as they do not have to carry heavy tools. This will also reduce the downtime of the pump. The field trials of the modified below-ground mechanism is being carried out. If this venture becomes successful, the entire maintenance scheme will go through revolutionary change.

HANDPUMP STUDIES IN THE IVORY COAST

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The Ivory Coast has a land area of 320,000 km² and is bordered to the south by the Atlantic Ocean, to the east by Ghana, to the west by Liberia and Guinea, and to the north by Mali and Burkina Faso. The country has three climate zones: equatorial, tropical, and Sudanese. Its hydrographic system is comprised of four major river basins--Cavally, Sassandra, Bandama and Comoe--and other small coastal rivers. The four major rivers run north-south and empty into the Atlantic Ocean.

The subsoil of the Ivory Coast is mainly crystalline and metamorphic. The only major sedimentary formations are from the Mesozoic Era and Tertiary Period (known as "terminal continental" in Africa) and are found along a narrow coastal strip stretching from the Sassandra westward, up to the border with Ghana to the east, and covering only 3 percent of the country.

There are also mountainous structures, alternating with generally narrow strips of flatter land and having a large number of folds (sometimes even vertical), with deposits of sandstone, schist, and sediment from volcanic rubble. Lava is sometimes found, as these structures have undergone relatively intense metamorphosis.

NATIONAL POLICY FOR POTABLE WATER SUPPLY

Because of the acute shortage of potable water in rural areas, in terms of both quality and quantity, the Government decided in 1974 to undertake an ambitious water supply program. In responding to the needs of the rural dwellers, the Government set the following objectives:

1. Use groundwater taken from wells and tubewells rather than the generally polluted surface water;
2. Target water production at 10-15 litres/day/inhabitant by 1982, and 20-30 litres/day/inhabitant from 1982 onwards.

On December 31, 1982, the provisional program based on the objectives was implemented, calling for the establishment of 12,500 village water points by 1985. Each water point is to produce at least 500 l/hr (the minimum being based on the number of inhabitants in the villages).

Project Area and Target Group

The program began in the savanna regions (center and north sections of the country) and in areas where rates of waterborne disease were relatively high. At present, more than two-thirds of the rural dwellers have potable

water. Until water supply systems are built in semi-urban areas, their inhabitants have been provided with water points in accordance to the size of their populations.

Execution

The Village Water Division of the Water Directorate (Ministry of Public Works, Construction, Postal Services and Telecommunications), which is currently implementing the national village water supply program, plays the role of a consulting firm. As in all projects, it carries out field surveys and geological, hydrogeological and geophysical studies to ascertain optimal works construction.

Needs Assessment

Under the village water supply program, a water point is built in all villages having at least 100 inhabitants in accordance with the following specifications:

1. One water point for every 100 to 900 inhabitants;
2. One water point for each additional 600 inhabitants.

When a water point built in a village with 600 to 900 inhabitants produces less than 12 m³/day, however, one or even two additional water points are provided to meet the needs.

Under this emergency program which began in 1975, a total of some 12,500 water points are to be built at an average rate of 1,500 per year. The target should be achieved by 1985. On December 31, 1983, about 11,000 water points had been built, of which one-third were wells and two-thirds were tubewells.

VILLAGE WATER POINTS

In addition to water drawn from springs, water is being taken from two types of wells now being built under the national water supply program, i.e., wells and tubewells. At present, no springs have been improved under the program, although they are potentially useful for supply in regions where they are abundant. Spring water should not be allowed to become contaminated by runoff water and should be filtered in order to remove fine suspended particles. The potability of the water should be guaranteed by protecting the area around the spring from animals, plants and other potential pollutants. Water collection per se would consist of preventing the water from flowing downstream by constructing a parallel epipedal tank of reinforced concrete, the walls of which would be perforated either upstream or at the base, depending upon the configuration of the spring.

Wells

Wells are generally built in those areas which have undergone extensive weathering (on an average of 15 to 30 m), found in the Ivory Coast in the substratum of coarse-grained rocks.

Two types of wells are now being built; the selection of type is based on the amount of support provided by the Alterites:

1. Wells with a single interior diameter of 800 mm in coarse Alterites that provide good support (granitic sand);
2. Wells with interior diameters of 600 to 800 mm in soil that provides poor support (sandy or kaolinic Alterites).

The casing of prefabricated reinforced concrete piping is positioned after the well is drilled. The pipes are placed so that they fit together perfectly. Strainers are placed inside the lower pipes up to the height of the water table. The bottom pipe contains a perforated slab 15 cm thick at its base, lying on a bed of gravel 50 cm deep. The annular space of the borehole is filled with gravel of a specific size, which acts as a filter.

At the surface, a concrete cover is sealed to the pipe column where it rises up above ground level. This slab has a manhole equipped with a padlock. The pump is installed on this slab. Around the wellhead, a 2.00 m x 2.00 m mud guard has a drainage spout for spilled water. In order for the well to be used year-round, the water must be 10 to 12 m deep during the rainy season and 7 to 8 m deep during the dry season.

Tubewells

Tubewells can range from at least 25 m deep to 100 m deep. They are sunk in granitic or schistose areas where the surface Alterites are not water-bearing. Tubewells are drilled with air hammers; sometimes the rotary method (drilling mud) is employed in Alterite layers. The diameter of the tubewell is 22 cm in the Alterites and 16 cm at the base. PVC tubing is used for the lining. A filter consisting of gravel of specific size fills the tubewell up to the top of the strainers.

MEANS OF PUMPING

All the wells have handpumps which allow for an hourly flow of 0.5 to 1.5 m³.

ABI Pumps. These are conventional pumps with piston, valves, hand-operated handles and pump rods; they have long been used on many wells in the Ivory Coast because of their durable construction and ease of maintenance. They are manufactured in Abidjan and have two drawbacks:

1. They are difficult to use beyond a depth of 35 m.
2. Because of their weight and design, they require heavy hoisting equipment for positioning or removal for repair.

Vergnet Hydropumps. These hydraulic pumps have been tested in the Ivory Coast. After several design modifications, they are almost ready for widespread use. These pumps are operated by a pedal and can produce 0.5 m³ of water/hour at depths of 60 m. Simple to assemble and requiring no special tools, they can be installed by a single person. One drawback is that the

cylinder has a fairly short life span and is relatively expensive to replace. About 3,000 such pumps are now used on village wells.

Hybrid pumps--ASM (ABI/Sofretes-Mengin) This new type of pump has the advantages of the two preceding models (hydraulic transmission and manual operation); in addition, two of them can be installed on a tubewell with an interior diameter of 5 inches. They are easy to maintain. The hybrid pumps can draw water from depths of more than 80 m, unlike the two models from which they were developed.

WATER POINT MAINTENANCE

Whether a water point can be used year-round depends on both the structure itself (type, technique used, equipment) and the means of pumping employed. Although there are virtually no problems with the wells themselves, (due to the monitoring, supervision of the works, and techniques employed), the same cannot be said of the pumps, which are a source of concern.

SODECI is responsible for keeping the water points in operation, for overseeing the pumps (including their replacement) and strainers, for carrying out civil works and for determining the bacterial count in the water. The cleanliness of the surrounding area is the responsibility of the villagers. The duties, as appropriate, are assigned to heavy or lightweight mobile brigades attached to SODECI regional offices and based at urban supply centers. Each brigade services 300 water points; for 1982, this meant 33 brigades attached to 22 bases servicing 9,700 water points.

The work mainly centers around circuits of 40 to 50 wells visited regularly for preventive care and emergency service, following notification of the head of the SODECI center. The SODECI brigades report to the Mobil Village Water Point Units attached to the Water Directorate. Quarterly meetings and printed forms have been instituted to help the groups with their work.

Maintenance was initially financed through a surcharge paid by urban subscribers; this was suspended in late 1980 because of a significant increase in the number of water points and replaced by an annual lump-sum fee of CFAF 60,000 per water point. This fee is paid directly to SODECI by the villagers upon receipt of an invoice.

Until 1980, maintenance costs for the water points were borne by the National Water Fund and financed by the surcharge on each cubic meter of water sold in urban areas. Eventually, with the increase in the number of water points, it was recognized that the surcharge would become very heavy and markedly raise the price of water. The Government therefore decided to have the beneficiaries, i.e., the villagers, cover maintenance expenses. In addition, a detailed survey authorized by the Ivory Coast on the condition of pumps found many deficiencies with the agency contractually responsible for maintaining the water points.

The situation may now be summarized as follows:

1. Breakdowns are numerous--only about 38 percent of the pumps operate properly.
2. The well platforms are often worn.
3. The cleanliness of the surrounding area is frequently not maintained; 68 percent of the platforms are dirty.
4. Eighty-nine percent of the water points are not properly enclosed, and the drainage in the surrounding area is poor.
5. SODECI servicing is too infrequent and will become even more so.
6. Adequate preventive inspections of current defects are made for only 12 percent of the pumps. This rate was previously 63 percent.

The villagers' contribution towards the maintenance of their water points with training and awareness-raising--training to remedy minor breakdowns and awareness-raising to enable them to cover maintenance costs (parts, labor, enclosure and drainage). The training will, however, be limited, since the villagers cannot handle all breakdowns themselves and call in the appropriate unit for major problems. The results of field studies now underway (SNES, ONSP, etc.), if encouraging, will certainly be fundamental in determining the best solution for ensuring a more efficient maintenance system.

E OF PUMP

In order to make the future maintenance system more economical, certain criteria should be taken into account in pump selection. Independently of the geological conditions (depth and fluctuations in water level), the following criteria should be taken into consideration:

1. Ease of operation and good yield;
2. Durability and reliability;
3. Simplicity of design and construction, with at least partial on-site manufacture possible;
4. Simplicity in maintenance and repair (easy access to worn-out parts), allowing some maintenance tasks to be delegated to the village community;
5. Lightweight design, for ease of transportation and assembly;
6. Assured availability of spare parts; and
7. Low investment and maintenance costs.

In addition, pump standardization seems to have many advantages and helps promote proper maintenance.

PRACTICAL CONDITIONS FOR PROPER MAINTENANCE

The distinction should be drawn here between special repairs and scheduled maintenance, the object of the latter being to prevent repairs through the regular provision of a series of maintenance and monitoring operations. It goes without saying that maintenance and repair operations for a group of pumps involve a host of difficulties. A series of factors must be taken into account and may be grouped under the following headings:

Program Initiation

1. Guaranteed long-term financing;
2. Sustained support from the authorities;
3. Appropriate organizational structure;
4. Sufficient number of pumps; and
5. Pump standardization--selection of a high-quality model requiring simple maintenance.

Implementation

1. Careful matching of personnel and maintenance equipment to pump type; and
2. Distribution of duties and good coordination between the national entity, which has the specialized personnel, physical resources and workshops, and the village community.

Execution

Regular inspections, systematic operations and assured supply of spare parts.

Organization

It would be difficult to make precise recommendations in this respect; however, a sound organization should be as decentralized as possible, and based on several factors, mainly:

1. The ability of the villagers to assume responsibility for certain operations (prior to this, they must be made more aware of the problems of water supply);
2. Pump type;

3. The nature and frequency of regular maintenance and monitoring operations.

CONCLUSION

Although the techniques of water point construction have been mastered by the companies and offices responsible for studies and monitoring, the major stumbling block in the village water supply program is the establishment and operation of an efficient organization to maintain the pumps.

The maintenance policy should at all times involve villager participation, a factor which is important for two reasons:

1. It instills a sense of security to the extent that the villagers will feel less dependent on a distant repairman.
2. It is more economical because service trips by a mobile repair brigade are always expensive.

HANDPUMP USE IN COMMUNITY WATER SUPPLIES:
AN INTEGRAL PART OF RURAL WATER DEVELOPMENT

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ABSTRACT

Handpumps are increasingly becoming an integral part of groundwater development in Kenya. Handpumps offer some tangible advantages in the development and provision of water supply to the rural people. This is evident in the development of shallow wells for small communities, where limited incomes are a major constraint to making water available to meet basic needs.

High fuel costs, shortages of trained manpower and lack of spare parts are major bottlenecks.

INTRODUCTION

The Government of Kenya has made considerable progress in development of water resources since attaining nationhood some 20 years ago, with the objective of improving the living conditions of the rural population. The Government is committed to bringing potable water within reasonable reach of all citizens by the year 2000.

This provision of water is practicable through integrated development of surface and ground water. Because of the adverse economic conditions, scarcity of resources, increasing depletion of surface water and great expense necessary for development, attention is now being turned to groundwater as a potential water resource for achieving the ambitious target. The envisaged groundwater development entails the use of water wells, handpumps and appropriate construction methods for the target communities. Kenya is well advanced in community "Harambee" efforts in development. The development of groundwater using simple and appropriate technologies is now going on in these areas of Kenya, with assistance from donors and the UN/World Bank agencies implementing the "International Drinking Water Supply and Sanitation Decade". The Government is grateful for this assistance and is now directly implementing one of the projects with the aim of providing recommendations on the suitability of the appropriate technology and the constraints in establishing a systematic implementation and operational framework.

Two-thirds of Kenya is semi-arid, and rainfall is scarce and erratically distributed. Surface runoff dries up after a short period. Thus, the need to develop groundwater is very great. Topographical factors and soil types make it difficult to construct big storage dams. In the rest of the region not covered by existing schemes and where rainfall is adequate, population

densities are high and water contamination is generally encountered, resulting in outbreaks of such waterborne diseases as cholera, bilharzia, etc.

It is therefore planned to tap groundwater free from surface contamination using boreholes and dug wells, most of them fitted with handpumps. Such development of simple water supplies allows for direct community participation through construction, operation and maintenance, as well as the application of simple tools and equipment in construction. It is envisaged that the provision of safe drinking water will greatly improve the health and vitality of the population, thus improving their productive and managerial capacities for utilising all other resources.

SHALLOW-WELL DEVELOPMENT PROJECTS

There are three major shallow-well development projects being implemented in different parts of the country.

Groundwater Development Project in Western Province

The project was initiated in February 1981, under a technical cooperation agreement between the Governments of Kenya and Finland signed in 1975. The project is being implemented by M/S KENFINCO, a Finnish consulting firm, mutually agreed upon by the Ministry of Water Development and the Ministry of Foreign Affairs of Finland. The project covers some 3650 km², and the work commenced in March 1981. Data collection on surface and groundwater and the preparation of a water supply development plan were completed in June 1983.

Hydrogeology

The project area is largely comprised of a relatively flat erosion surface of deep-weathered granites. Where precipitation is adequate, an abundance of relatively shallow aquifers of low permeability exist, with the depth of water commonly less than 15 m. Both seismic and resistivity methods are used to investigate the nature of the formations. In summary, the weathered crystalline rock aquifers are generally unsuitable for large-scale groundwater abstraction, but the low yields available are adequate for small domestic water supplies by use of handpumps.

Project Programme

The objectives of this programme are as follows:

- (i) Completion of hydrogeological investigations, geophysical measurements and spring identification;
- (ii) Construction of wells;
- (iii) Installation of handpumps and construction of aprons at all wells;
- (iv) Monitoring of the operation and maintenance of handpumps;
- (v) Training of local communities on public health and its relationship to sanitation and water use.

Progress

The construction of wells is done in two ways, i.e. hand-dug and drilled. The latter method is used for supplying water to schools, clinics, and market centers. Communities are now participating in digging their own wells. The wells are equipped with either Nira or India Mark II Handpumps.

Dug Wells

This is an old indigenous technology, and there are very many experts available locally. As of June 1984, 129 old dug wells have been fitted with handpumps and are operational. Thirty-eight others are still awaiting installation. Depths vary between 3.5 to 16.5 m, the average being 8.8 m. Water levels vary from 1.9 to 7.0 m. Community participation in well digging is normally carried out during the dry period to avoid striking elevated water levels occurring during the wet season and to minimize caving-in problems.

Drilled Wells (Boreholes)

More than 140 boreholes sited by seismic surveys have been successfully drilled to an average depth of 57.7 m by an Atlas Copco Aquadrill rig, using the Odex Principle to penetrate the overborder. Ninety of these have been fitted with handpumps; 33 boreholes were abandoned due to low yields and/or technical problems.

Costs

A dug well costs about US\$897 (KShs. 13,000) compared to US\$2,759 (KShs. 40,000) for drilling a borehole. Each well is expected to serve a community of about 130 people. The annual operational cost for a handpump/well is about US\$0.7 (KShs. 10) per person per year. These costs are rough estimates as no water tariff has been devised since the project still maintains the handpumps. Actual operational costs will emerge when the running and maintenance have been handed over to the communities. Rural water supply is a utility from the Government, and water is charged at a flat rate of US\$1 per month per connection.

Groundwater Quality

Chemical analysis indicates that the quality of groundwater in the project area is generally good (BARIDI). In some cases, high iron (Fe) contents and acidic waters have been noticed. Care is taken not to use metallic screens due to their corrosive effects. Water level measurements are monitored on a weekly basis in 56 wells and in 12 boreholes. Seasonal fluctuations range from 2 to 5 m.

Lake Basin Shallow-Wells Project

This shallow-well programme in Nyanza Province was initiated by the Lake Basin Development Authority in 1982 under a Dutch Government bilateral aid programme and is being executed by a Dutch consulting firm, DHV Consulting

Engineers, in collaboration with the Lake Basin Development Authority. During the pilot phase, 41 handpumps (SWN 80 & 81) were installed in drilled and dug wells.

The pilot programme was established to investigate:

- (i) Feasibility of constructing low-cost shallow wells in the province for water supply in rural areas;
- (ii) Methods, materials and equipment to be used, taking into consideration the idea that:
 - (a) Execution of the work should be simple;
 - (b) Maintenance should be minimal;
 - (c) Equipment and materials to be used should be locally produced;
 - (d) The well water should be used for other purposes, e.g., small-plot irrigation, cattle dip water supplies and livestock development.
- (iii) Possibilities of guaranteeing future maintenance through ownership of wells and training of local staff.

In summary, the project aimed to provide easily accessible safe water in adequate quantities at a cost within the economic capabilities of the communities and through facilities which are locally available and can easily be operated and maintained at the local level.

Project Area

Nyanza Province has a land area of 12,526 km² and consists of four districts with a total population of 2,643,956, according to the 1979 census. Out of these, 2.4 million people live in the rural areas with poor sanitation facilities.

Project activities

Initially, a survey was carried out to collect relevant hydrogeological, sociological and technical information and data and to establish the feasibility of the shallow-well programme. It was discovered that there were 450 wells dug under the Ministry of Health programme and about 200 - 250 wells constructed privately. Most of the wells were equipped with locally made handpumps, out of which (at the time of the survey) less than 10 percent were operational. All these wells were hand-dug and are mostly lined with concrete rings with depths varying from 2 to 30 m.

Well Construction Methods

The siting is through non-technical methods, and the wells are generally located in valleys rather than on slopes or hills and in suitable geological

formations. Drilling was carried out by manually operated equipment and in some cases, wells were dug.

Service Levels

Most large-scale water supplies in the area run by the Ministry of Water Development are concentrated in the densely-populated urban areas; only a very small percentage of the rural population relies on treated/safe water supplies. In all, about 18 percent of the population is served with improved water supplies. Due to the scarcity and sparsity of permanent water sources, people walk up to 7 km to collect water.

It is estimated that 90,000 people fetch water from shallow wells in Kisii and the Northern parts of Siaya; most of the wells are open. Frequent occurrence of cholera in parts of the Lake Basin is caused by the poor quality of water, and the provision of wells free from pollution will greatly improve the present situation.

The results from the pilot project indicated that about 250 to 300 people use one handpump, and it is anticipated that this source, when completely brought into use, will serve 30 to 40 percent of the rural population.

The water quality of the shallow wells is generally good, except in some parts of the Kano plains and around Lake Victoria, where high saline levels were encountered.

The Ministry of Water Development has now established a monitoring programme on the quality of water and upgraded a laboratory in the town to carry out chemical analysis and give advisory services to the local people.

From the data collected, the following decisions were made:

- (i) Hand drilling is recommended in alluvial deposits; however, such deposits are very scarce in the project area;
- (ii) Hand digging or machine drilling is recommended in weathered pre-Cambrian rocks which outcrop in over 50 percent of the project area;
- (iii) Five - ten percent of the total number of wells can be constructed either by hand-drilling or digging, but the majority require machine-drilling.

South Coast Handpumps Project

The Kenya Government, having confirmed its participation in the International Drinking Water Supply and Sanitation Decade, set up this programme in 1981. This project is funded by the Swedish International Development Agency under the auspices of UNDP and management support from the World Bank (INT/81/026). Unlike the preceding two projects, this project is managed and implemented by a team of Kenyans from the Ministry of Water Development. The Ministry is also contributing drilling equipment and support facilities. Although Kenya has been active in rural water supply projects since 1970, the objectives of improving the living conditions of

theeessessless-developed rural masses has not been achieved due to technical problems, e.g., lack of community participation, spare parts, etc. As a result, the Kenya-Sweden Rural Water Supply Programme is now giving priority to small water supplies, designed in such a way as to make possible local participation in the implementation, operation and maintenance of the schemes. The primary aim of this project was based on the idea that "in regions where shallow aquifers exist, the most feasible and economic method to provide small rural populations and those living in villages with adequate water supplies is by wells equipped with handpumps."

Objectives of the programme

The long-term objectives of the project are as follows:

- (i) To reduce the cost and improve the dependability of rural water supply which depends on handpumps for water abstraction;
- (ii) To promote and identify technologies that will reduce the cost and dependability of handpumps suitable for Kenyan conditions;
- (iii) To establish local manufacture of suitable handpumps.

Other immediate objectives included drilling and equipping 50 boreholes and protecting and covering 150 wells, all equipped with handpumps. The aspect of community participation was also found to be crucial and efforts have been made to seek the views and ideas of the people on how the project can be implemented to guarantee their participation in operation and maintenance. A proposal has been made for a large rural water supply and sanitation programme to include the whole of Kwale District beginning next year.

Project Area

The project area covers 300 km² in the Diani and Msambweni locations of the Kwale District. This District lies in the southeastern corner of Kenya between Mombasa and the Tanzanian border and has an area of 8257 km² and a population of 288,363 according to the 1979 census. The existing water supplies serve over 10 percent of the population, while the majority use water from dug wells and other traditional sources, which include ponds, rivers and springs.

Hydrogeology

The project area is underlaid by Pliocene sands and gravels which are in turn overlaid by the coral reef and Pleistocene sands and clays. The unconsolidated sandy horizons form good aquifers. The coral reef is sometimes fissured and consists of coral fragments and sands. The aquifers are highly permeable and productive, drawdowns are small and the water quality is excellent. The yields are normally in the range of 20 to 120 litres per minute. Water levels vary between 2 to 20 metres.

Activities

The project began in 1981 when a full-time project coordinator was seconded to the project and water committees formed. Appropriate borehole sites were selected by the project coordinator with assistance from local divisional staff from the Ministries of Health and Social Services. The criteria for choosing sites were based on hydrogeological considerations, water needs of the villages and requests from villagers themselves.

An inventory was carried out of the existing wells, and over 130 wells were identified. Water levels were measured and monitoring on chosen wells is being carried out to determine water level fluctuation due to precipitation and drought patterns. Water samples are also collected for bacteriological and chemical analyses.

At the start of the project, the communities showed some dislike of the programme and this necessitated undertaking a sociocultural study to identify their source of worries. The study discovered that two preceding handpump programmes (UNICEF--1964, and Australia-Kenya Cooperation--1978) had installed handpumps and covered wells after which the pumps failed and no provision for repairs had been made; thus, the wells became inaccessible. It was therefore decided that the services of sociologists were necessary in any handpump programme so that the people's needs and aspirations are taken into consideration in the project implementation. In this regard, a Kenyan NGO--the Kenya Water for Health Organization--has been involved to help in community liaison, assess community needs, organize community commitment to improvement of water supplies and long-term maintenance. Their second role is to increase awareness in matters of hygiene, establish training methods and materials and run training programmes related to water supply and sanitation. At the moment, one full-time sociologist is carrying out the above duties with help from another part-time staff member from KWAHO.

Borehole Construction

The construction of boreholes began in July 1983, and by June 1984, 30 boreholes had been completed, out of which 25 have been installed with handpumps. The protection and covering of wells with removable slabs in the event of failure were delayed until the communities' confidence was restored.

The drilling is carried out by two lightweight surveyor rigs capable of drilling shallow holes. The depths vary between 20 to 40 m, and the water levels vary from 2 to 20 m.

As the geology of the area consists of a coral reef, coral breccia and unconsolidated fine sands with clays and silt, it is important that wells are gravel-packed with suitable gravel, and the screen slot sizes measured at less than 0.75 mm for successful borehole and pump life.

This programme was essentially a handpump testing programme. Five types of handpumps have been installed and are now being monitored for their performance, dependability and durability. Since most of the pumps have been in use for less than six months, it is too early to draw any conclusions at the moment. However, the Malawi-type handpump has been performing better than the others in terms of ease of installation, performance and yields. It is

also worthwhile to note that the India Mark II and Malawi types are now being manufactured locally, the latter with modifications.

The testing programme involves the following:

<u>Pump type</u>	<u>On Site</u>	<u>Installed No.</u>
Blair (Zimbabwe)	x	0
Duba Tropic (Belgium)		X (expected)
India Mark II (India)	x	L (Locally made)
Malawi Pump (Malawi)	x	11
Nira (Finland)	x	3
Petro Pump (Sweden)	x	5
SWN (Holland)	x	1
Vergnet (France)	x	5

Service Level

It is estimated that an approximate average of 250 people use one handpump. If it is approximated that each family uses about 160 litres/day, then it can be deduced that each pump produces about 5 m³/day. The present pumps are therefore serving about 6,000 people. About 40 to 50 percent of the population of the area can therefore be served. The cost of each borehole, including the handpump, is approximately KShs. 30,000. Recurrent running costs have not been worked out, but it is hoped that they will be within the means of the population.

Other Handpump Programmes

The aforementioned programmes are the largest programmes in the country, but there are other handpumps programmes elsewhere in the country contributing in their own small way to the betterment of rural water supplies.

Forty Duba Tropic II pumps have been installed in Lodwar by the Diocese of Turkana, while 14 handpumps have been installed in boreholes drilled by the Ministry of Water Development in West Pokot. The Kitui District Resources Study has also proposed the construction of 1,000 wells equipped with handpumps. The applicability of handpumps has become such an important alternative that more attention is foreseen for the coming years.

OPERATION AND MAINTENANCE OF HANDPUMPS

Most communities, especially those who have seen piped schemes, may see the introduction of handpumps as inferior technology. To worsen the situation, the frequent high rate of failure due to poor quality and lack of

maintenance and repair make them even more unpopular. It is, therefore, important that a simple, durable and easily maintainable handpump is identified. It is equally important that adequate attention be paid to maintenance and repair aspects. Since the main idea is to have the community maintain and repair handpumps, adequate consideration should be given to encouraging community participation in the whole exercise of installing handpumps. It is therefore important that pumps should be manufactured locally with a provision of adequate spare parts. The major problems with the use of handpumps are as follows:

- (i) Poor quality of handpump design and manufacture;
- (ii) Lack of training of communities in maintenance skills, use of tools for repair, spare parts, transport and supervision;
- (iii) Complicated underground components;
- (iv) Need for frequent lubrication;
- (v) Overestimation of the capabilities of handpumps, especially where water is being pumped from deep levels;
- (vi) Lack of preventive maintenance never being taken seriously.

The maintenance of handpumps will, therefore, depend largely on serious public education and training of villagers and tradesmen, and readily available spare parts.

COMMUNITY PARTICIPATION

The success of handpump programmes will largely depend on the community itself. It is therefore important that communities are involved from the very beginning of the programme, especially women who are the main water drawers. During project implementation, many villagers, craftsmen, tradesmen, and other organized groups should be trained in operation and maintenance. The general public should be educated on the benefits of clean water to their health and general well-being. Committees should be formed to run each water point and encouraged to collect contributions--either an initial contribution from households or monthly payments to be kept for maintenance. In this case, the villages can use trained craftsmen for maintenance and repair. Another idea is for the village committees to prepare small gardens using wastewater for irrigation. The proceeds from the produce can be used for maintenance. Community maintenance has the effect of cutting transport costs and reducing initial investments.

It is important to bear in mind that many rural people will not appreciate the health benefits derived from clean water immediately and that the handpump is not very different from the traditional sources. For this reason, the urgency to maintain pumps and repair breakdowns will generally be lacking. It is therefore important that the field social workers and public health officers are given training so that they can always provide the same to the communities in which they work. The work for social workers and public health officers is maximising the direct and indirect benefits arising from

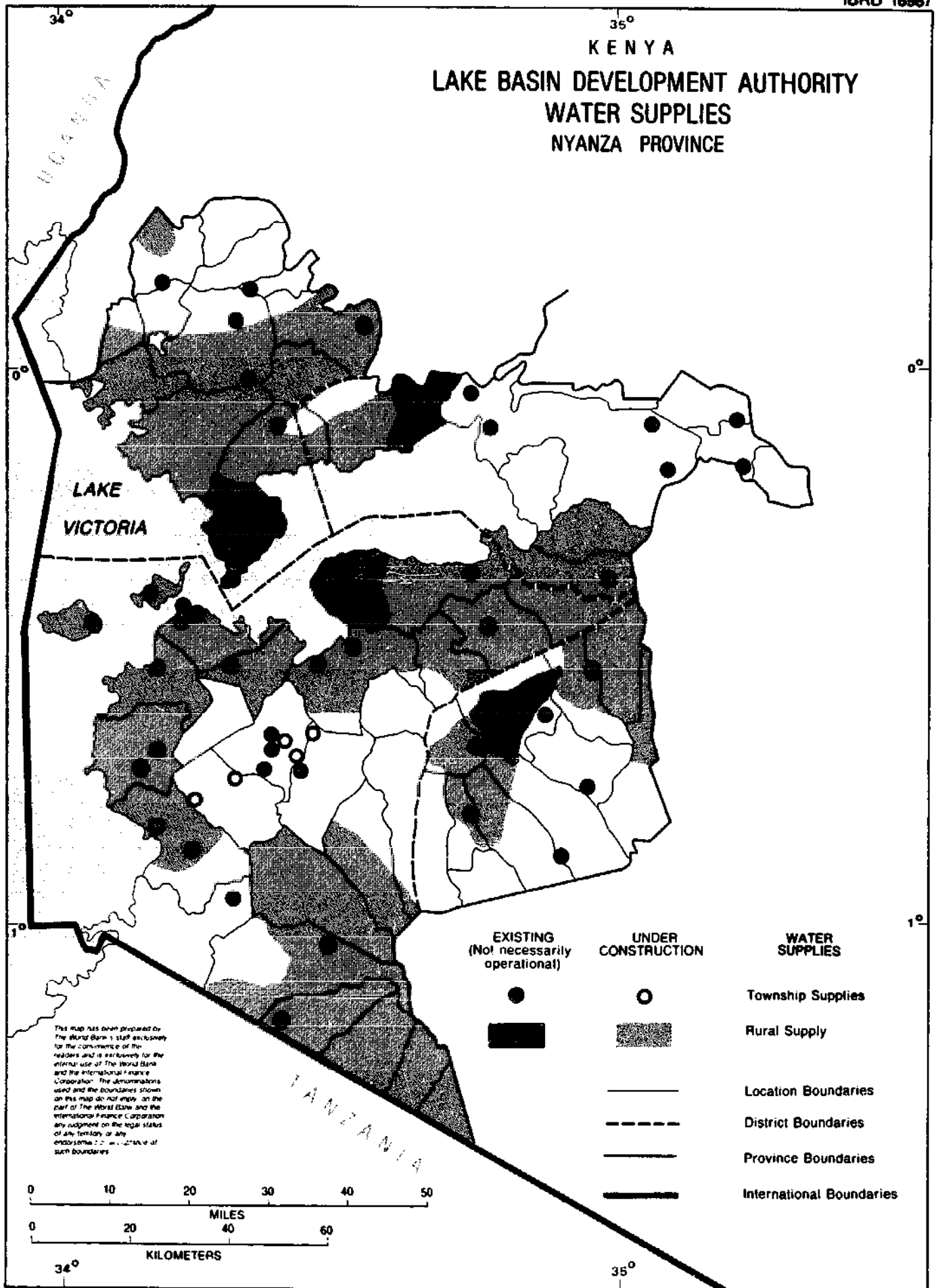
the provision of improved water supplies and ensuring that those benefits continue in the years to come--an odious task which needs the support of all.

A report on operation and maintenance was prepared by KENFINCO and based on the data collected after one and a half years of use of pumps in the Rural Water Supply Development Project in Western Kenya.

CONCLUSION

Handpumps installed in wells are definitely the cheapest alternative for supplying water to rural communities, because of low capital investment and running costs. Use of hand-dug wells should be encouraged, as it is easy to involve the community in their construction. Drilled wells, especially deep ones, should be completed in such a way as to allow for expansion when dictated by a community's development, e.g., replacement of a handpump with a motorised pump. When monitoring and performance data have been obtained, one to two types of pumps that are found to be most suitable should be manufactured locally and a sufficient spare-parts supply provided for.

As of now, it is apparent that despite all other demands being met by the handpump, the success of any handpump programme will depend on how the community is trained in its operation, maintenance and repairs. Pump Committees, consisting largely of women, craftsmen, and tradesmen should be properly trained in the handpump installation, removal, repairs and preventive maintenance and supported by local "funds." In this regard, the roles of social workers and public health officers is paramount. All trained artisans, as well as those showing special aptitude, should be provided with repair tools and operating manuals.



Project Names	No. of Boreholes/ Dug Wells	No. of Pumps Installed	Remarks
1 Rural Water Supply Development Project, Western Kenya	307	210	The Project covers an area of 3650 km ² . 23% of the boreholes failed from either low yield or techni- cal problems. Commenced Feb. 1981.
2 Lake Basin Shallow Wells Project, Nyanza	Not indicated 40	41	The project began in 1982 March. The data is correct as of June 1984. This was a pilot project to cover the whole of Nyanza.
3 South Coast Hand- pumps Project Msambweni, Kwale District	30	25	The project covers an area of 300 km ² . It began in July 1983.

HANDPUMP APPLICATIONS IN RURAL WATER SUPPLY
PROJECTS IN THE PHILIPPINES

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BACKGROUND

Country Profile

The Philippines is comprised of more than 7,100 islands with a total land area of 300,720 km². Almost 95 percent of the land is located in eleven of the largest islands with two, Luzon and Mindanao, accounting for two-thirds of the total land area. A map is presented on the following page for reference.

A mild, tropical climate is typical for the country throughout the year. Average annual temperature varies from a maximum of 32°C to a minimum of 22°C, while relative humidity varies from a low of 76 percent to a high of 83 percent.

In 1980, the population of the country was estimated at 49 million persons, with an annual growth rate of 2.8 percent.

In 1982, the Gross National Product (GNP) was placed at ₱336.016M (\$40 million). Agriculture, fishing, and forestry contributed 26 percent of this figure; industry, 36 percent; and other services accounted the remaining 38 percent. Average per capita income was ₱6,622.00 (\$367.88).

Indicators of the quality of life in the country, especially for health conditions and health facilities, generally have been satisfactory and continue to improve.

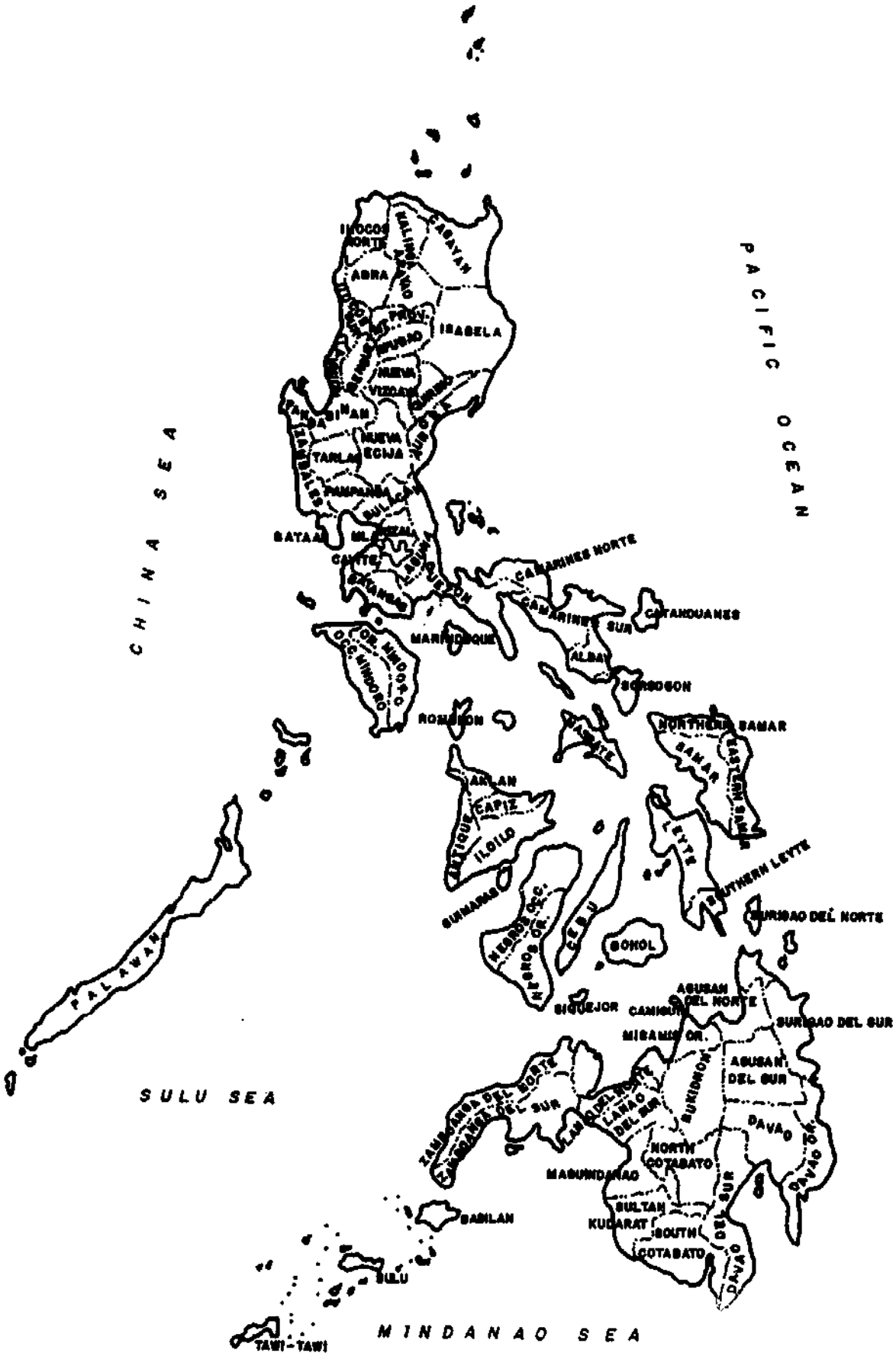
Existing Water Supply Situation

As of 1981, an estimated 53 percent of the total population of the Philippines was being served by public water supply. The service coverage was 82 percent of the population in Metro Manila and its adjoining areas, while only 47 percent in the rural areas. The rest of the population depended mainly on water from open wells, rain water cisterns, lakes, rivers and streams, many of which were of doubtful quality.

Levels of Water Service

Concerned government agencies in water supply development have been providing three levels of water service to the people, namely:

MAP OF THE PHILIPPINES



- a. Level I - Point Source (A well or a developed spring serving about 50 households or less);
- b. Level II - Communal Faucets (A system composed of a source, a piped distribution network and communal faucets);
- c. Level III - Individual Connections (A system with a source, a piped distribution network and household connections).

Illustrations of these levels of water service are shown in Annex 1.

The type of service provided to a community depends largely on such factors as population density, source of water, acceptability of the proposed project to the end users, and development cost.

Rural Population Coverage

There are 45,672 public wells in the country, of which 31,250 are in the rural areas serving an estimated 14 million inhabitants. Of the total number of public wells, 38,820 are operational. About 15 percent of these wells, most of which were installed 10 to 20 years ago, require rehabilitation or replacement.

There are more than 3,000 developed springs, serving about 5.4 million persons, mostly in the rural areas. The country abounds in springs, but most of them are located far from clusters of population.

Communal faucets or public standpipe systems numbering 1,469 serve about 900,000 persons in the rural areas. The majority of water sources are deep wells.

Water Resources Conditions

The Philippines has abundant water resources, having an average annual precipitation of 2,260 mm, an average annual run-off of about 256,900 million cubic meters (with 90 percent available for use) and large reservoirs of groundwater covering some 50,000 square kilometers and concentrated mostly beneath major river basins. The distribution of these water resources varies widely with time and location.

Institutional Arrangements

The government has structured the water supply sector as follows:

The National Water Resources Council (NWRC) formulates all framework plans and policies for water supply in the country.

The Metropolitan Waterworks and Sewerage System (MWSS) provides water supply in Metro Manila and other contiguous areas that may be added to its jurisdiction according to its charter.

The Local Water Utilities Administration (LWUA) remains responsible for the creation of water districts which provide water supply to areas with a population of 20,000 persons or more.

The Rural Waterworks Development Corporation (RWDC) provides water supply in the rural sector and other areas not covered by the MWSS and the LWUA.

The Ministry of Public Works and Highways (MPWH) serves as the principal implementing arm of the RWDC for engineering and construction.

The Ministry of Local Government (MLG) implements the Barangay Water Program with financial assistance from the US Agency for International Development (USAID).

The Ministry of Health (MOH) promotes safe water supply and exercises surveillance on the quality of water.

Rural Water Supply Program

The establishment of the water supply sector paved the way for the formulation of the Rural Water Supply and Sanitation Master Plan for the period 1982 - 2000. This master plan embodies specific policies, targets, and action programs for the provision of potable water supply to the rural communities. It also provides the framework for coordinated development activities by all entities concerned within this sector.

Considering the extent of the water supply needs and the resources that can be mobilized to meet these requirements in the shortest possible time, the following targets have been set:

- a. Immediate Targets. By the end of 1984, all barangays in the country shall have a minimum of Level I service; all existing nonoperational public wells shall be rehabilitated, replaced or repaired jointly by the government and the end-users; about 50 percent of the "poblaciones" and 10 percent of the rural "barangays" shall have at least Level II service; and about 25 percent of the poblaciones shall have Level III service.
- b. Intermediate Targets. By the end of 1986, about 30 percent of the rural barangays shall have a minimum of Level II service; the incremental demand for repair and rehabilitation of wells shall be met; all cities or clusters of population with 50 households or more shall have a minimum of Level II service.
- c. Long-range Targets. By the end of 1990, about 50 percent of all barangays shall have a minimum of Level II service; by the end of 1995, all poblaciones shall have Level III service; and by the year 2000, 70 percent of the cities or clusters of population shall have a minimum of Level III service, while 30 percent shall maintain the Level I service.

The required investment in order to attain the aforementioned targets are enumerated hereunder by stage of implementation (figures are presented in million pesos, as of December 1981).

Level of Water Service	Stage I (1982-1985)	Stage II (1986-1990)	Stage III (1990-2000)	Total (1982-2000)
Shallow Wells	61.95	71.41	94.71	228.07
Deep Wells	245.96	184.03	309.60	739.59
Springs	59.18	21.15	121.50	201.83
Others	8.75	23.25	104.25	136.25
Construction	375.84	299.84	630.06	1,305.74
Rehabilitation	40.80	18.00	12.00	70.80
LEVEL I	<u>416.64</u>	<u>317.84</u>	<u>642.06</u>	<u>1,376.54</u>
Source Development	199.32	193.22	281.41	673.95
Distribution	800.00	775.00	1,130.00	2,705.00
LEVEL II	<u>999.32</u>	<u>968.22</u>	<u>1,411.41</u>	<u>3,378.95</u>

STANDARD WATER WELL DESIGNS

One of the most widely used water supply sources in the country today is groundwater extracted from wells and springs. The three types of wells commonly used in the Philippines are described below.

Shallow Well

A shallow well is fitted with a cast-iron suction pump and with either 38-mm \emptyset (1/2" \emptyset) PVC casing pipes and screens or 50-mm \emptyset (2" \emptyset) GI casing pipes and well points. These wells have a water level of not more than 5 meters (20') in depth. The average well depth is 12 meters (40'). It cannot be converted as a source for a Level II system.

Intermediate Well

An intermediate well is fitted with a 46-mm \emptyset (1 13/16" \emptyset) cylinder pump and 10-mm \emptyset (3/8" \emptyset) suction rods on a 50-mm \emptyset (2" \emptyset) GI casing pipe with well point and wooden handle. These wells have a water level of 6 meters (20') to

30 meters (98') in depth. The average well depth is 50 meters (165') and average cylinder setting is 25 meters (82'). It cannot be converted as a source for a Level II system.

Deep Well

A deep well is fitted with larger diameter casing pipes and screens, suction pipes with a cylinder, piston rods and wooden handle. These wells have a water level of more than 30 meters (98'). The average well depth is 60 meters (1971). It can be converted as a source for a Level II system.

DRILLING EQUIPMENT AND METHODS

There are two kinds of equipment widely used in drilling wells—the percussion rig and the rotary rig. Experiences in well drilling are aptly described as follows:

Percussion Rig

The percussion rig, which drills boreholes by repeatedly dropping a heavy weight into them, may be mechanical or manual. In constructing a well with a mechanical percussion rig, the drilling tools, well casing screen, and other materials are suspended and manipulated from a derrick. The percussion bit is then alternately dropped and raised in and out of the borehole to loosen the ground. The loosened particles are then brought to the surface by means of a bailer. This operation is continued until the desired depth of the well being constructed is reached.

The manual type of drilling rig is suspended through a pulley and tied on top of a tripod being operated by a man who alternately pulls and releases the rope connected to the drill bit. The drill bit is hoisted up when the rope is pulled and drops down when the rope is released. The alternate raising and dropping of the drill bit loosens the ground. The loosened particles are then brought to the surface by means of a bailer or a similar tool.

Manual methods of drilling are not always successful in constructing a well, especially in areas where the groundwater level is very deep. In such cases, a light-jet percussion rig is used to drill holes 38 (1 1/2") to 150 mm (6") in diameter, up to a depth of 70 (230") meters. This portable light rig can drill through soft rock and hardpan. Operation techniques are simple and can be easily learned. Wells drilled with this type of rig are much cheaper than a borehole drilled with a standard percussion rig.

Rotary Rig

Rotary rigs are more varied in structure and operation. In the normal rotary process, mud is pumped down to the center of the drill stem or shaft. The mud returns through the annular space between the drill stem and the borehole walls, carrying with it loosened materials from the bit. The pressure of the flow forces mud into the borehole wall, which seals and supports it. Other rotary methods use water and high pressure pumps or compressed air to blow the loosened materials to the surface. For these types of rotary drilling, various bits can be used, from the simple roller bit for normal work

to the diamond drill for more complex work. A bit tipped with industrial diamonds penetrate the hardest rock formations.

The advantage of the rotary rig over the percussion rig is its faster drilling speed and ability to penetrate harder rock. The rotary rig, however, is more expensive than the percussion rig.

HANDPUMPS

Several million people in the Philippines depend on handpumps for their drinking water supply, and major handpump programs are underway. There is now a growing awareness of the important role handpumps play in providing acceptable drinking water supply in the rural and urban-fringe areas.

Existing Handpumps

Existing handpumps in the country today are generally categorized as either shallow-well or deep-well pumps. Shallow wells are fitted with surface-mounted cast-iron handpumps, while deep wells are fitted with medium- or heavy-duty handpumps.

There are two kinds of shallow-well handpumps: single-purpose and multi-purpose. There are also two kinds of deep-well handpumps: medium-duty and heavy-duty. Illustrations of these handpumps are presented in Annex 2.

Applications

Below are the different situations under which handpumps are applied:

TYPE OF WATER FACILITY

APPLICATIONS

1. Single-purpose shallow-well handpump
This is suitable in areas where the water level is not more than 6 meters (20') deep. It is also applicable in places where people fetch water in containers. It can serve up to 30 households with an average investment cost of ₱110.00 (\$6.11) per household.
2. Multi-purpose shallow-well handpump
This is also suitable in areas where the water level is not more than 6 meters deep. It is applicable in areas where people fetch water in containers and through hoses (because of the provision of a nozzle in the pump). It can also serve up to 30 households with an average investment cost of ₱110.00 (\$6.11) per household.
3. Medium-duty deep-well handpump
This type of handpump is applicable in areas where the water level is more than 6 meters (20') deep, with an average cylinder setting of 25 meters (82'). It is also applicable in areas where the water system will not be converted into a communal faucet system (Level II). It can serve up to 50 households with an average investment cost of about ₱300.00 (\$16.6) per household.
4. Heavy-duty deep-well handpump
This is used in areas where the water level is more than 30 meters (98') deep, with an average cylinder setting of 40 meters (130'). It is applicable in areas where the water system will be converted into a communal faucet system (Level II). It can serve up to 50 households with an average investment cost of ₱850.00 (\$47.20).

Handpumps Being Tested

The Philippines is being extended assistance by the World Bank and the United Nations Development Programme (UNDP) under the "Rural Water Supply Handpumps Field Trials and Technological Development Project", which is being implemented jointly by the RWDC and MPWH through its Project Management Office for Rural Water Supply (PMO-RWS). The project aims to improve the design and manufacturing techniques of village-level operation and maintenance (VLOM) pumps and to promote in-country production of handpumps suitable for local conditions at the least cost possible.

At present, studies on the following types of handpumps and their corresponding screens are being undertaken:

- a. Cast-iron shallow-well handpumps (surface-mounted) with 38-mm \emptyset (1-1/2" \emptyset) PVC casing pipes and screens.
- b. Cast-iron shallow-well handpumps (surface-mounted) with 50-mm \emptyset (2" \emptyset) GI casing pipes with screen drive points.
- c. Deep-well handpumps with 50-mm \emptyset (2" \emptyset) GI casing pipes, 46-mm \emptyset x 610-mm (1-13/16" \emptyset x 24") all-brass cylinder and valve group, and 10-mm \emptyset (3/8" \emptyset) pump rod.
- d. Deep-well handpumps with 100-mm \emptyset (4" \emptyset) PVC casing pipes and screens, 38-mm \emptyset (1-1/2" \emptyset) GI drop pipe and 57-mm \emptyset x 610-mm (2-1/4" \emptyset x 24") all-brass cylinder and valve group.
- e. Deep-well handpumps with 100-mm \emptyset (4" \emptyset) GI casing pipes and 38-mm \emptyset (1-1/2" \emptyset) GI drop pipes, with 57-mm \emptyset x 610-mm (2-1/4" \emptyset x 24") all-brass cylinder and valve group and 100-mm \emptyset (4" \emptyset) low-carbon screen.
- f. Deep-well handpumps with 127-mm \emptyset (5" \emptyset) steel casing pipes, 63-mm \emptyset (2-1/2" \emptyset) GI drop pipes, 57-mm \emptyset x 610-mm (2-1/4" \emptyset x 24") all-brass cylinder and valve group and low carbon screen.

Scope of Field Trials

The ongoing handpump field trials and technological development are being undertaken in the provinces of Pampanga, Bulacan, Nueva Ecija and Batangas, all on the Luzon Island and covering about 145 barangays or villages. These localities are considered representative for the three topographical zones of the country which range from plains to mountains to coastal areas, with varying geological formations.

The field tests involve approximately 200 handpumps, which include both commonly used pumps in the country and a number of experimentally designed handpumps from other developing nations installed to determine their effectiveness and applicability to local conditions.

Handpumps and Screens Being Tested

A total of 160 units of handpumps, together with corresponding screens in each well, are being tested as follows:

- a. Shallow wells--30 units of "Jetmatic" handpumps with robo-screens; 20 units of "Eureka"-type cylinder pumps with locally made pumpheads, no screens; 20 units of Eureka-type cylinder pumps with Malawi pumpheads, no screens; and 30 units of Blair pumps.
- b. Deep wells--30 wells with 100-mm \emptyset (4" \emptyset) PVC casing pipes and screens, 63-mm \emptyset (2-1/2" \emptyset) drop pipes, 57-mm \emptyset x 610-mm (2-1/4" \emptyset x 24") brass cylinders with wooden pump handle assemblies; 15 wells with 100-mm \emptyset (4" \emptyset) PVC casing pipes and screens, 63-mm \emptyset (2-1/2" \emptyset) drop pipes, 57-mm \emptyset x 610-mm (2-1/2" \emptyset x 24") brass cylinders with Malawi pumpheads; and 15 units of Mark II pumps.

One essential component of a well is the screen, usually used in areas with certain geological formations, such as sand and gravel deposits. The screen allows for the flow of water, while segregating soil particles which usually cause the rapid wear of the pump cylinder or piston assembly. For this purpose, a low-cost spiral-slotted PVC well screen is being field tested to monitor its performance and effectiveness under various field conditions.

DRILLING AND HANDPUMP COST

As of March 1984, the costs of drilling/constructing various wells and installing handpumps were as follows:

TYPE	DRILLING/CONSTRUCTION COST	HANDPUMP COST
1. Shallow-Well	₹ 3,160 (\$175.55)	₹ 477 (\$26.50)
2. Intermediate Deep-Well (Medium-Duty)	15,100 (\$838.88)	1,600 (\$88.88)
3. Heavy-Duty Deep-Well (with steel casing)	42,400 (\$2355.55)	5,545 (\$308.05)
4. Heavy-Duty Deep-Well	33,350 (\$1833.33)	5,545 (\$308.05)

OPERATION AND MAINTENANCE COSTS

Studies revealed the following coverage costs of operating and maintaining wells.

<u>Type</u>	<u>Average Yearly Maintenance Cost</u>
1. Shallow-Well	₱ 200.00 (\$11.11)
2. Intermediate Deep-Well	500.00 (\$27.78)
3. Heavy-Duty Deep-Well (with steel casing)	700.00 (\$38.89)
4. Heavy-Duty Deep-Well (with PVC casing)	700.00 (\$38.89)

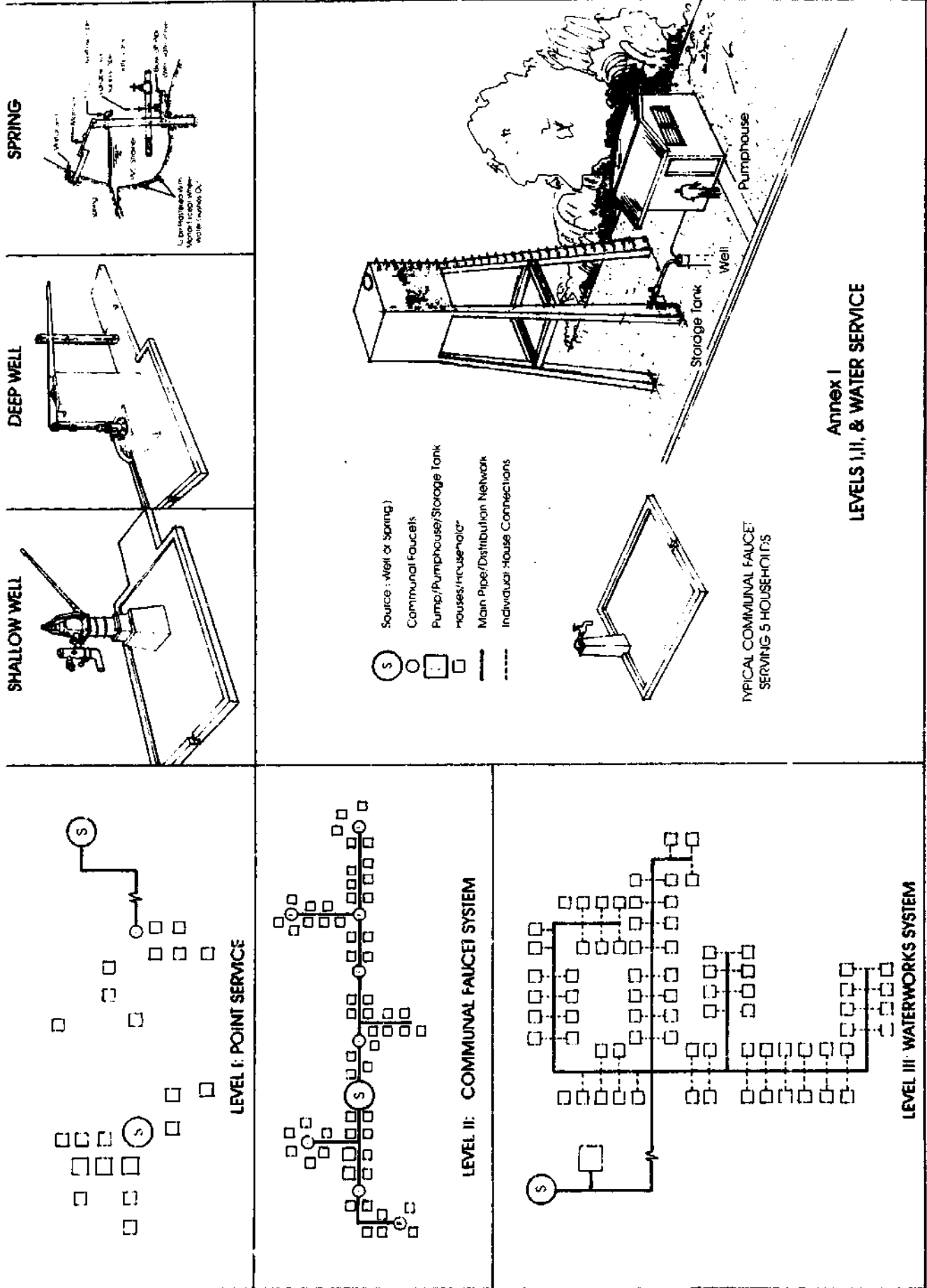
ISSUES

1. Standard water well designs were developed on the basis of actual field cases or situations; however, traditional designs are still widely used. Other designs, particularly the medium-duty deep-well pump, using PVC casings and screens, and the Blair Pump, are being adopted at a very slow pace and require acceleration because of their suitability and lower costs.
2. With a program under which 10,000 wells per year are constructed with about 250 drilling machines, optimum utilization of these drilling machines is inevitable.
3. Although there are several cases wherein water users effectively maintain their handpumps, in most instances, they are not maintained properly. The same predicament is being experienced with pump repairs.
4. There is no accurate measure of water consumption or water flow of handpumps, except an estimate of per capita consumption within the service area, which also includes water for other purposes outside domestic use and waste/excess water.
5. Local pump manufacturers can easily produce handpumps that are sold in large quantities, but are relatively hesitant to participate in the development of handpumps, due to the nonprofitability of such an undertaking.
6. Handpumps produced are tested by the manufacturers themselves because the Government does not have the facilities for such tests. There is no measure, except field trials, to check the accuracy of the test certificates.
7. Villagers and/or water-users generally accept only handpumps with which they are familiar and are apprehensive to accept new designs.
8. Turnover of well drillers and system operators is constant; hence, there is a dire need for a regular training program on well drilling and system operation and maintenance.

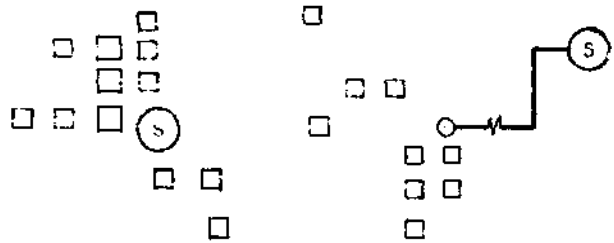
9. Drilling and handpump costs continue to increase at a high rate (25 percent annually) never experienced in the past.

CONCLUSIONS

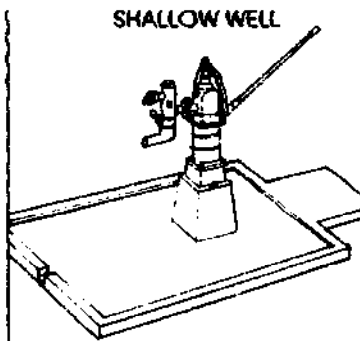
1. The Philippines will continue to depend largely on groundwater sources for its drinking water supply needs, especially in the rural areas.
2. Standard designs of wells and handpumps will be improved upon or modified as a result of research being conducted, with due consideration given to field suitability (i.e., can water users easily operate and maintain the system) and cost.
3. Water users accept new or improved designs of handpumps, provided an adequate and proper information dissemination campaign (i.e., features, benefits, previous experience) is undertaken.
4. Testing and evaluation of handpumps should be a continuing undertaking, so as to develop and obtain the most suitable type at the least possible cost.
5. The percussion-type drilling machine is more extensively used than the rotary type, essentially because the former is much cheaper. However, portable rotary drilling rigs and semi-rotary machines are gaining in popularity.
6. Institution building should be strengthened.
7. A longer warranty period is requested by the government from manufacturers to guarantee quality of workmanship on handpumps being produced.
8. There is a major necessity to periodically monitor (e.g. semi-annually) a reasonable random sample of villages using handpumps in order to establish historical data on operation and maintenance practices and costs for inputs in planning activities. Possible improvement(s) in operation and maintenance can likewise be instituted.
9. A Village Caretaker's Log Book or registry book of information on the operation, maintenance and repair of water facilities is indispensable and should be continuously developed.



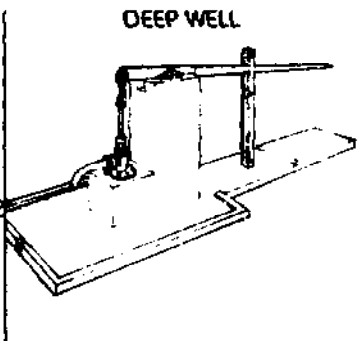
**Annex I
LEVELS I, II, & WATER SERVICE**



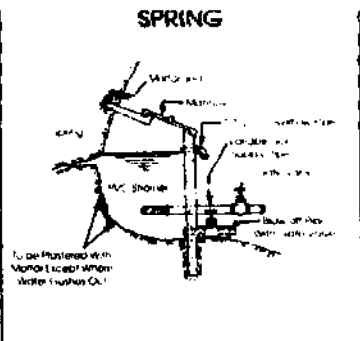
LEVEL I: POINT SERVICE



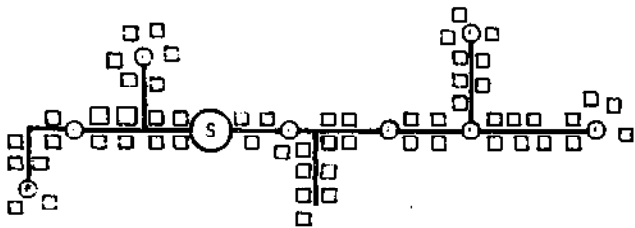
SHALLOW WELL



DEEP WELL

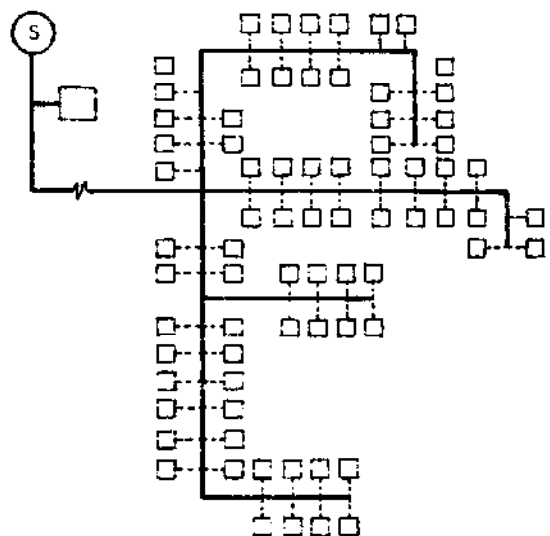


SPRING

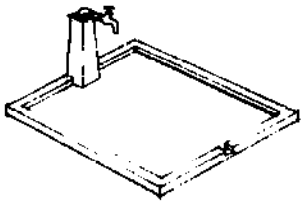


LEVEL II: COMMUNAL FAUCET SYSTEM

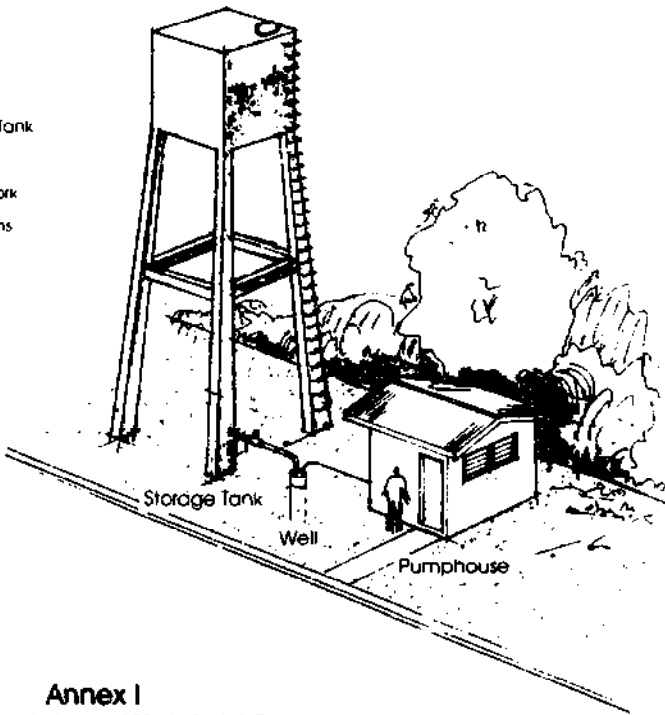
- Source (Well or Spring)
- Communal Faucets
- Pump/Pumphouse/Storage Tank
- Houses/Household
- Main Pipe/Distribution Network
- Individual House Connections



LEVEL III: WATERWORKS SYSTEM



TYPICAL COMMUNAL FAUCET SERVING 5 HOUSEHOLDS



Annex I
LEVELS I, II, & WATER SERVICE

STANDARD WELL DESIGNS

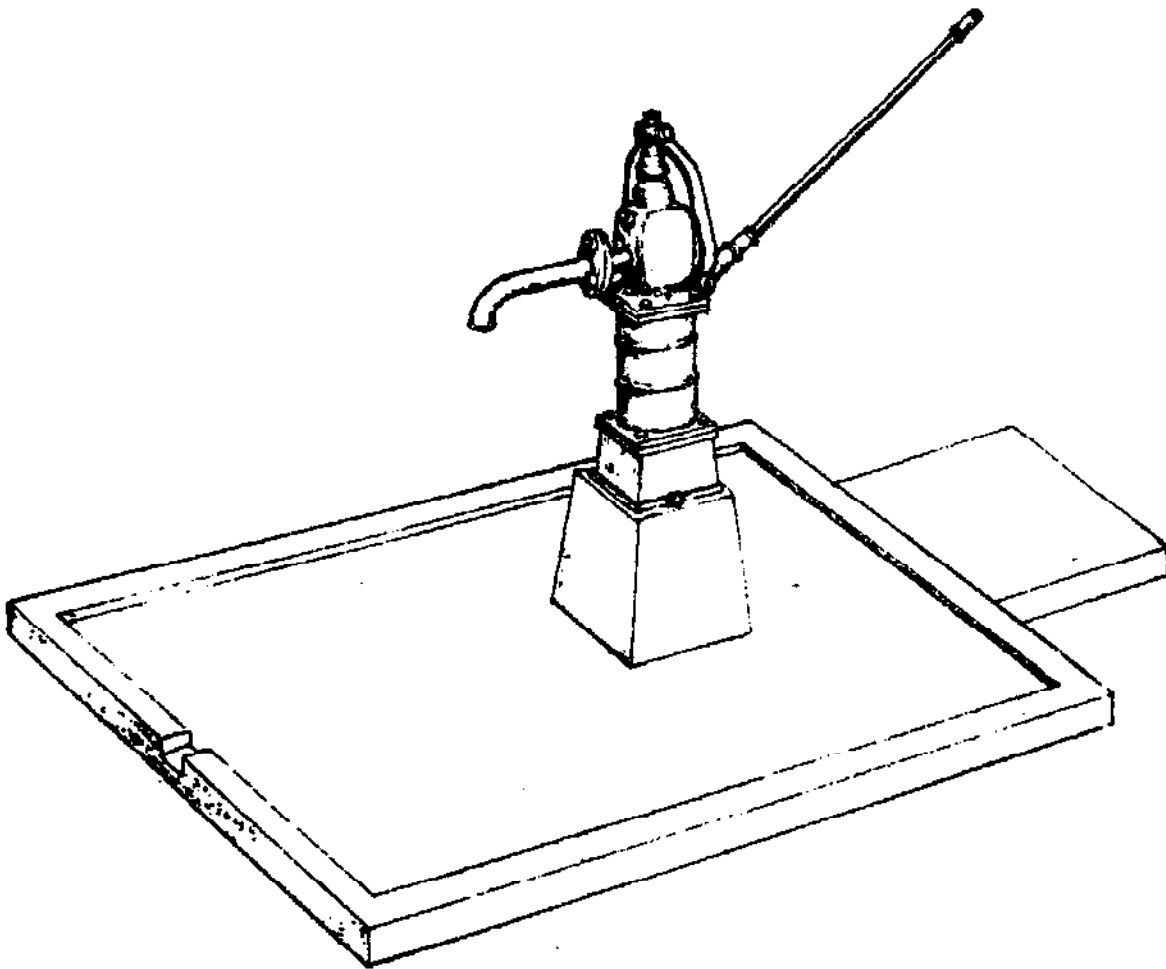


FIGURE 1 SINGLE-PURPOSE SHALLOW-WELL HANDPUMP

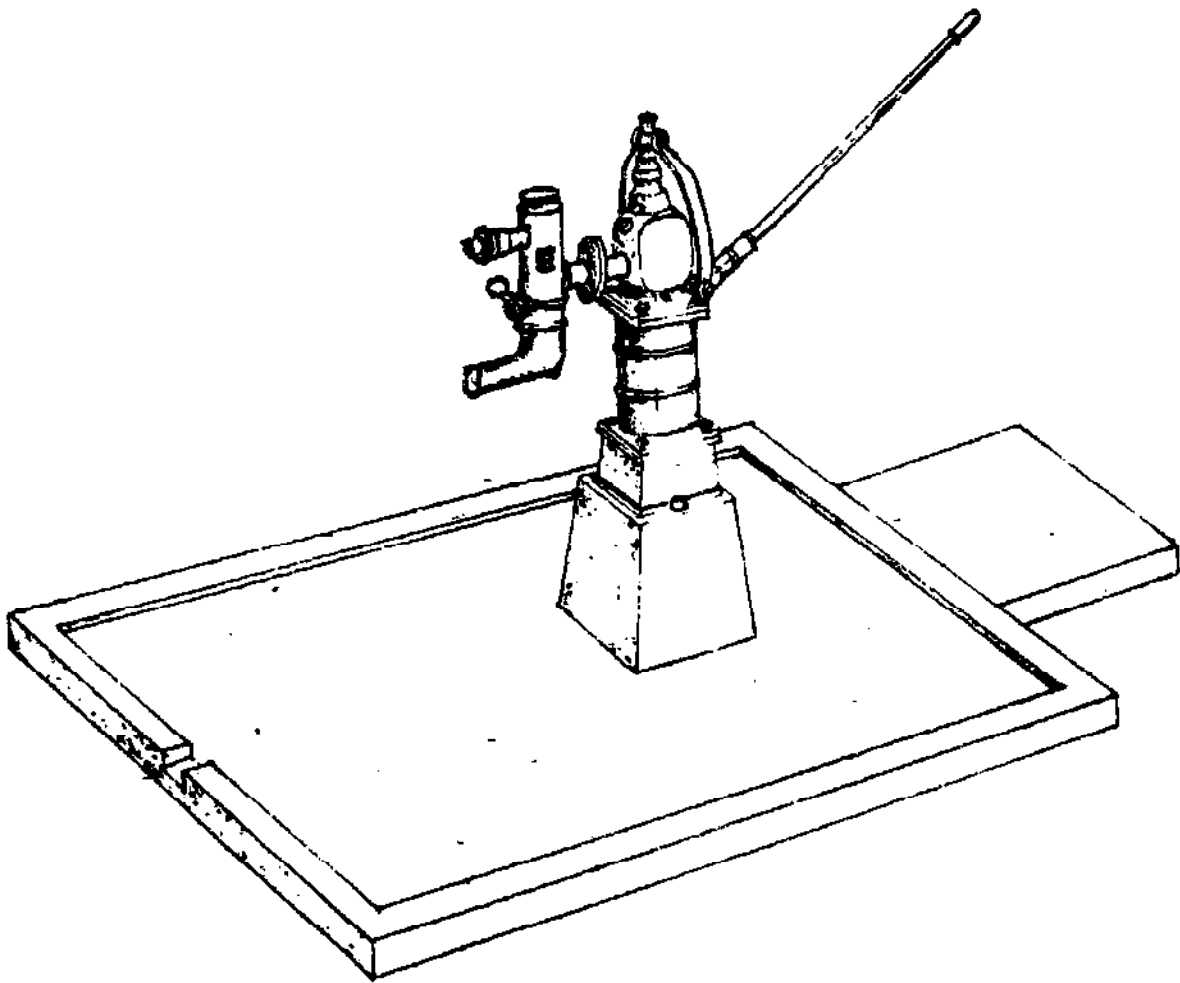


FIGURE 2 MULTI-PURPOSE SHALLOW-WELL HANDPUMP

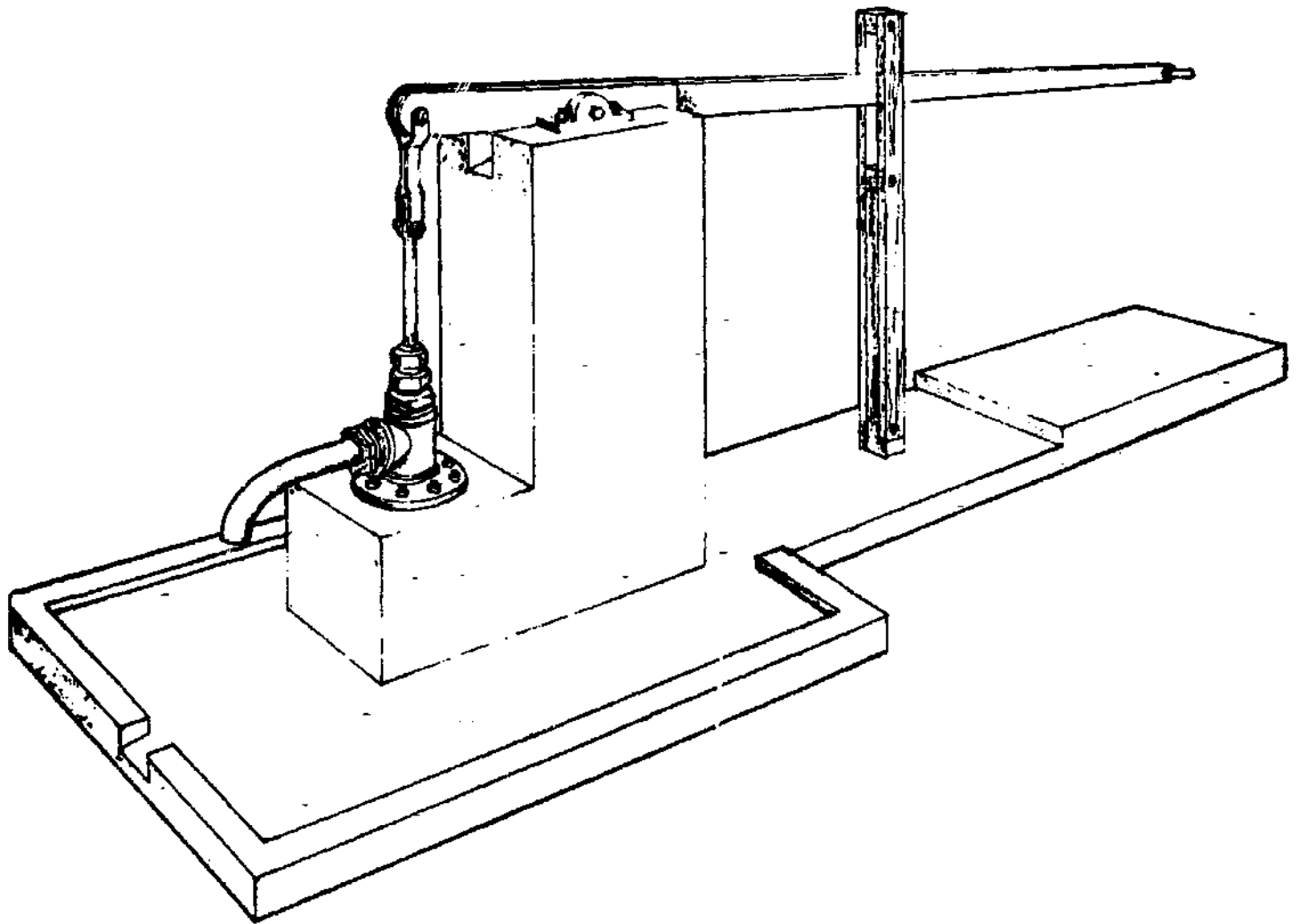


FIGURE 3 MEDIUM-DUTY DEEP-WELL HANDPUMP

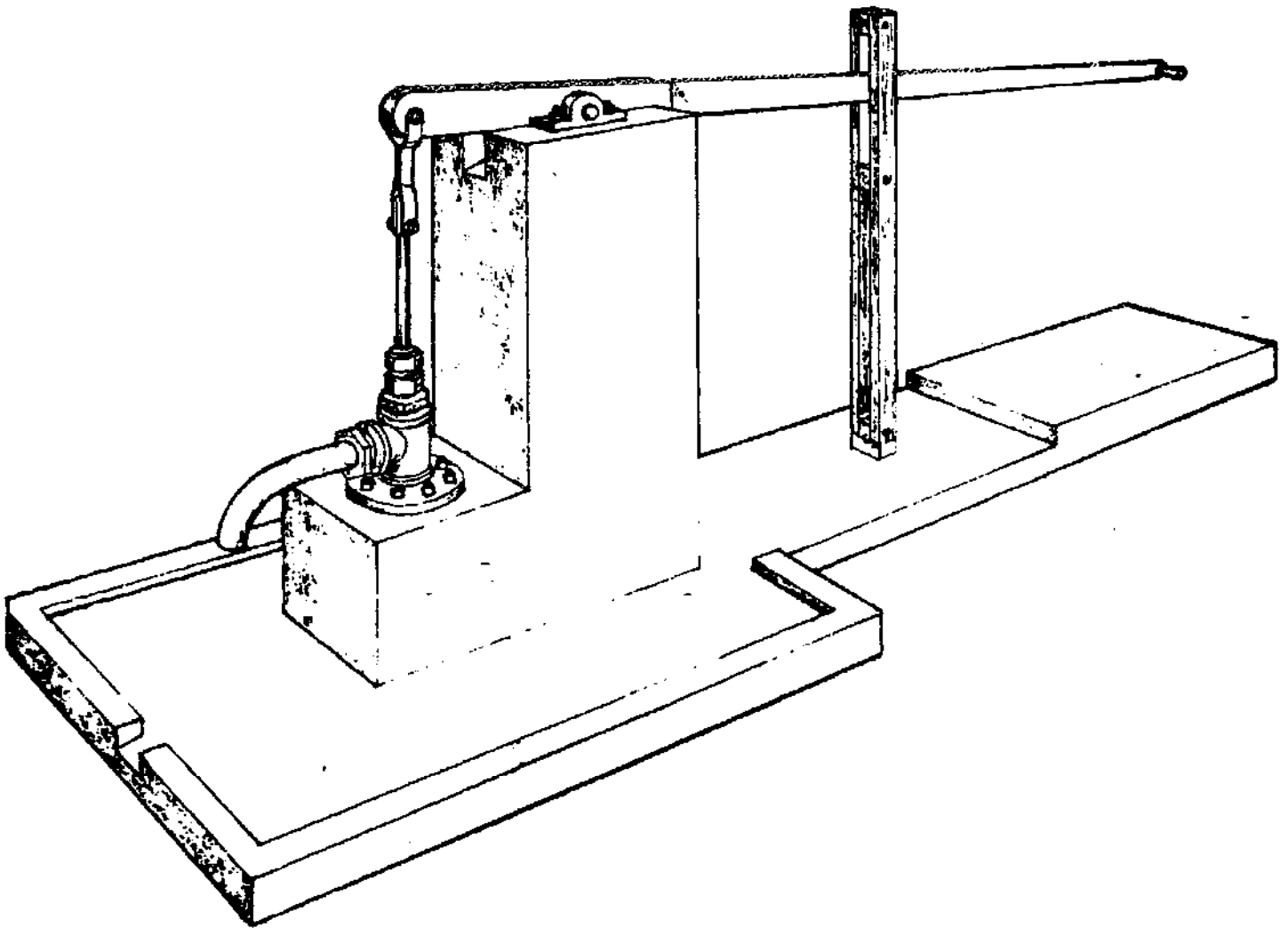


FIGURE 4 HEAVY-DUTY DEEP-WELL HANDPUMP

COSTS OF DRILLING/CONSTRUCTING WELLS
(As of March 1984)

SHALLOW-WELL PUMPS

QUANTITY	DESCRIPTION	UNIT COST	TOTAL
1 set	Handpumps	₱ 477.27	₱ 477.27
5 bags	Portland Cement	40.00	200.00
1 m ³	Gravel	100.00	100.00
1/2 m ³	Sand	200.00	100.00
6 pcs.	2" x 3" x 16" Form Lumber	20.00	120.00
1 pc.	4' x 8' x 1/4" Plywood	60.00	60.00
2 kg	C.W. Nail (Assorted Sizes)	10.00	20.00
3 pcs.	1-1/2"Ø x 10' GI Pipe with Coupling (Plain)	409.09	409.09
1 pc.	1-1/2" x 10' GI Pipe with Coupling	136.36	136.36
	Subtotal		1,622.72
	FREIGHT CHARGES (5% of Material Cost)		81.14
	DIRECT AND OVERHEAD		
	Salaries and Wages		
4 men x 4 days	16 Man-days	25.00	400.00
Transportation Allowances	20% of Direct Labor Cost		80.00
Social Charges	5% of Direct Labor Cost		20.00
	Subtotal		500.00
	FUEL AND OIL		
60 litres	Gasoline	6.50	390.00
8 litres	Motor Oil	18.00	144.00
1-1/2 lbs.	Grease	12.00	18.00
	Subtotal		552.00
	EQUIPMENT RENTAL	Lump Sum	400.00
	TOTAL		₱3,155.86 (₱3,160.00)

MEDIUM-DUTY DEEP-WELL PUMPS

QUANTITY	DESCRIPTION	UNIT COST	ESTIMATED COST
I. DRILLING OF WELL AND INSTALLATION OF 2"Ø GI PIPES			
10 pcs.	2"Ø x 20' GI Pipes with Coupling (Sch. 40)	₱ 400.00	₱ 4,000.00
1 pc.	2"Ø Brass Well Point	500.00	<u>500.00</u>
			4,500.00
	Labor		<u>4,000.00</u>
	Subtotal		8,500.00
II. WELL DEVELOPMENT			
5 bags	Portland Cement	40.00	200.00
3 m ³	Gravel	180.00	540.00
2 m ³	Sand	90.00	<u>180.00</u>
			920.00
	Labor		<u>300.00</u>
	Subtotal		1,220.00
III. INSTALLATION OF HANDPUMP AND PLATFORM CONSTRUCTION			
1 set	1-13/16"Ø x 24' All-Brass Cylinder	800.00	800.00
12 pcs.	3/8"Ø x 10' Sander Rods	90.00	1,080.00
1 set	Yoke Assembly	20.00	20.00
1 set	Staffing Box Assembly	100.00	100.00
1 pc.	1-1/2"Ø Short Pipe	20.00	20.00
1 pc.	2"Ø x 1-1/2"Ø Tee Reducer	30.00	30.00
1 pc.	2" x 3" x 6' Wooden Handle	50.00	50.00
16 pcs.	100mmØ Steel Reinforcing Bars	35.00	560.00
7 bags	Portland Cement	40.00	280.00
3 m ³	Gravel	180.00	540.00
2 m ³	Sand	90.00	180.00
2 pcs.	1/4" x 4' x 8' Plywood	100.00	200.00
10 bd.ft.	2" x 3" x 16" Apitong	56.00	560.00
2 kg	CW Nail (Assorted Size)	14.00	28.00
1 kg	#16 Tie Wire	15.00	<u>15.00</u>
			4,623.00
	Labor		<u>884.00</u>
	Subtotal		5,507.00
TOTAL			₱ 15,227.00 (₱ 15,200.00)

HEAVY-DUTY DEEP-WELL PUMPS

QUANTITY	DESCRIPTION	UNIT COST	TOTAL
13 pcs.	5"Ø x 10' Steel Casing Pipe	₱ 1,000.00	₱ 13,000.00
1 pc.	Drive Shoe for 5"Ø Casing	572.75	572.75
1 set	Handpumps	4,545.45	5,545.45
1 pc.	4"Ø x 5" Steel Screen	2,500.00	2,500.00
4 pcs.	2-1/2"Ø x 20' GI Column Drop Pipe	454.50	1,818.00
1 pc.	2" x 6" x 10" Wooden Handles	90.00	90.00
6 pcs.	1" x 6" x 12" Form Lumber	20.00	120.00
8 pcs.	2/8" x 20' R.B.	30.00	240.00
10 bags	Portland Cement	40.00	400.00
2 kg	2-1/2" GI Nail	14.00	28.00
1-1/2 kg	#16 GI Wire	15.00	15.00
3 m ³	Sand and Gravel	180.00	540.00
	Subtotal		24,869.20
	FREIGHT CHARGES (5% of Material Cost)		1,178.60
	DIRECT AND OVERHEAD		
	Salaries and Wages		
	7 men x 30 days	210 Man-days	25.00
			5,250.00
	Transportation Allowances	20% of Direct Labor Costs	1,050.00
	Social Charges	5% of Direct Labor Costs	263.00
	Subtotal		6,563.00
	FUEL, OIL AND LUBRICANTS		
600 litres	Diesel	450.00	2,700.00
300 litres	Gasoline	650.00	1,950.00
5 litres	Motor Oil	18.00	90.00
2 lbs.	Grease	12.00	24.00
	Subtotal		4,764.00
	EQUIPMENT RENTAL		
	Lump Sum		5,000.00
	TOTAL		₱ 42,374.80 (₱ 42,400.00)

HEAVY-DUTY DEEP-WELL PUMPS
(WITH PVC CASING)

QUANTITY	DESCRIPTION	UNIT COST	ESTIMATED COST
I. DRILLING OF WELL AND INSTALLATION OF 4"Ø CASING PIPES AND SCREEN			
12 pcs.	4"Ø x 6m PVC Casing Pipe Class 12.5	₱ 400.00	₱ 4,800.00
1 pc.	4"Ø x 3m PVC Screen (Slot No. 20)	920.00	<u>920.00</u>
			5,720.00
	Labor		<u>12,190.00</u>
	Subtotal		17,910.00
II. WELL DEVELOPMENT			
10 bags	Portland Cement	40.00	400.00
8 m ³	Gravel	180.00	1,440.00
4 m ³	Sand	90.00	360.00
24 hrs.	Pumping Test	50.00	<u>1,200.00</u>
			3,400.00
	Labor		<u>680.00</u>
	Subtotal		4,080.00
III. INSTALLATION OF HANDPUMP AND CONSTRUCTION OF PLATFORM			
1 set	2-1/4"Ø Brass Cylinder	2,000.00	2,000.00
8 pcs.	2-1/2"Ø x 20' Pipe (Sch. 40)	500.00	4,000.00
1 set	Complete Yoke Assembly	20.00	20.00
10 pcs.	5/8"Ø x 10' Sucker Rod	100.00	1,000.00
1 pc.	4"Ø PVC Plug	70.00	70.00
1 pc.	4"Ø Steel Flange (Upper)	300.00	300.00
1 pc.	1-1/2"Ø GI Tee	25.00	25.00
1 pc.	1-1/2"Ø GI Short Pipe (Spout)	20.00	20.00
1 pc.	2" x 3" x 9' Wooden Handle	60.00	60.00
1 set	Stuffing Box Assembly	100.00	100.00
6 bags	Portland Cement	40.00	240.00
2 m ³	Gravel	180.00	360.00
1 m ³	Sand	90.00	90.00
16 pcs.	10mmØ Steel Reinforcing Bars	35.00	560.00
2 pcs.	1/4" x 4' x 8' Plywood	100.00	200.00
80 bd.ft.	2" x 3" x 16" Apitong	450.00	360.00
2 kg	C.W. Nail, Assorted Sizes	14.00	28.00
1 kg	#16 Tie Wire	15.00	<u>15.00</u>
			9,448.00
	Labor		<u>1,889.00</u>
	Subtotal		10,337.00
TOTAL			₱ 32,127.60 (₱ 32,350.00)

HANDPUMP APPLICATIONS FOR RURAL COMMUNITY
WATER SUPPLY IN SRI LANKA

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Sri Lanka is an island situated in the Indian Ocean, within the Latitudes of 6 and 10° North and Longitudes 80 and 81° East. It has an area of 65,610 square kilometres. In 1983, the population of Sri Lanka numbered 14.5 million persons.

The country has a mountainous area in the south-central region, ranging in elevation from 900 to 2,100 m; this area is surrounded by a belt which is about 300 to 900 m in elevation. The coastal plains occupy the rest of the island; with the exception of the northern area, all are narrow regions.

Sri Lanka has a tropical climate with a mean temperature ranging between 27 and 28°C in the plains. The higher elevated areas are cooler. The island is exposed to two monsoons: the Southwest Monsoon between April and September and the Northeast Monsoon between October and March. On the basis of rainfall distribution, Sri Lanka can be divided into two zones. The wet zone comprises the southwest area and covers about a quarter of the island, with average rainfall of approximately 2,400 mm. The dry zone extends over the rest of the Island, with an average rainfall of approximately 600-1,200 mm or less. The relative humidity in the wet zone varies generally from about 70 percent during the day to about 90-95 percent during the night. In the dry zone, these figures are about 5 percent lower.

The common infectious diseases in the country are typhoid, infectious hepatitis, diphtheria and diarrhoeal diseases.

Geologically, approximately 90 percent of the island consists of crystalline rocks of the Precambrian age, and the remaining 10 percent located in the coastal plains consist of sedimentary rocks. Alluvial deposits can be found in limited amounts along the major river beds. The north and northwest coastal areas consist of a sedimentary karat limestone belt. These areas have been investigated by deep drilling.

Some high potential-yield aquifers have been located in the northwest belt. The depth of these aquifers range from 60 to 250 m, with artesian conditions existing in some areas. In selected sedimentary basins, a number of tubewells have been constructed, with yields ranging between 450 and 1,350 litres per minute. These tubewells are used for agriculture and water supply schemes. In some parts of this belt, water has a very high level of salinity.

The developed water basins have a salinity rate ranging from 100 to 500 mg/l. The south coastal area also has a high level of salinity.

Traditionally, the need for exploitation and utilisation of groundwater arose in areas where surface water sources were scarce and limited. In Sri Lanka, groundwater exploitation was mainly restricted to the sedimentary formations until 1979. The rural community in Sri Lanka used dug wells, tanks, rivers and springs to meet their requirements. When these sources ran dry during drought, they sometimes dug pits in tank beds or river beds to collect water, and had to travel long distances to collect water from these unprotected sources.

In 1979, under a new groundwater project, the National Water Supply and Drainage Board, with UNICEF aid, drilled about 200 test wells in the hard rock areas of the dry zone on a trial basis. Technical support for the hydrogeological investigation was provided by WHO. About 70 percent of these wells had enough water (i.e. more than 12 l/p/m) to allow for installation of handpumps. In a few places, high-yielding wells, producing about 1,000 l/p/m, were discovered; these wells were used as intake wells for piped water schemes for small towns. As the pilot project produced favourable results, UNICEF assistance was extended to further drilling and installation of handpumps. Similarly, technical support for the groundwater programme continued from WHO. At the end of 1983, about 1,400 deep wells had been drilled in hard rock areas under this programme, and the successful wells have been supplied with India Mark II deep-well handpumps. The drilled wells in these areas are 36 to 75 metres deep, with casing provisions down to an average of 15 m; the suction of each pump is kept at approximately 30 m below the ground level. The average water table is about 5 to 15 metres deep, with the variations between the wet and dry periods of one to two metres. The total cost of drilling a 5" (130 mm) tubewell to a depth of 75 metres in hard rock is about US\$600. Maintenance of drill rigs, hammers, drill bits, drill pipes, fuel filters for the compressors, hammer oil, support trucks, grinding wheels and spare parts costs about US\$300 per well, and these expenses are incurred by UNICEF. The cost of fuel, drilling crews and the site investigation staff is about US\$300, and this amount is provided by the National Water Supply and Drainage Board.

The India Mark II Deep-Well Handpump costs about US\$400, including spare parts required for maintenance over a period of 5 years. The installation of the pump with a reinforced concrete apron and outlet drains cost about US\$100. As such, the total cost for complete installation is about US\$500. India Mark II Deep-Well Handpumps are used for most of the installations in deep wells in Sri Lanka. At present, about 1,500 pumps have been installed in the dry zones by various agencies.

The India Mark II Deep-Well Handpump consists of a 2 1/2" or 3" \emptyset pump cylinder, 1 1/4" \emptyset column pipes and 1/2" connecting rods. This pump can stand up to rough use, and it has been observed that a heavily used pump requires replacement of bucket washers approximately once every six months. The only disadvantage in this pump is that for any repairs in the cylinder or even for replacement of the bucket washers, the whole suction pipeline has to be pulled out; this work must be carried out by skilled workers using appropriate tools. In order to overcome this problem, we are now testing the pump with 75-mm PVC riser pipes as opposed to the 1 1/4" GI pipes and the pump cylinder. If this test is successful, pump installation and replacement of bucket washers will become a very simple operation, as the connecting rods together with the piston can easily be pulled out or lowered with a limited number of tools. In shallow-well pumps, the connecting rods and piston can be

removed separately. Few other types of imported and locally made pumps have been tested on wells on a trial basis, but according to the performance records available, the India Mark II pumps appear to be the best of all.

There are few shallow-well projects in the hill country and in the wet zone. There is no scarcity of water in these areas, but the traditionally used open dug wells are not protected. In these areas, the hand-dug wells are now lined with 100-mm concrete rings. The depth of wells varies from 5 to 15 metres. The top is covered, and handpumps are fitted on the cover slab. In one of the districts in the hill country, the Government of Finland is drilling wells and installing "Nira" handpumps, which are made in Finland and are capable of raising water from wells of up to 36 m in depth. Until now, about 400 pumps of this type have been installed in this part of the country. In another district (Kalutara), the following types of handpumps are being field tested under the UNDP/World Bank Project:

1. Wasp
2. Inalsa
3. SAID
4. Tara Bangladesh
5. Sihilase
6. Sarvodaya L4
7. India Mark II

The tests carried out thus far have shown that the India Mark II, Inalsa and USAID pumps perform better than the other types.

To carry out maintenance of pumps installed in all these areas, voluntary caretakers are appointed from the community. These caretakers are given a two-day training course (including health aspects) by the NWS&D Board.

The pump breakdowns are reported to the district office by the caretakers, and the pump mechanic appointed by the Board is sent with the necessary tools to carry out repairs. The mechanic gets support from the villagers in case he has to pull out the suction pipes for any repairs in the cylinder.

The Government and the various agencies who carry out drilling and pump installation expect to entrust the pump maintenance works to the community by giving them necessary spare parts, tools and proper training. They are also experimenting with entrusting the aprons and outlet drains to the community; recently this has proven to be successful in the Anuradhapura district.

IMPROVEMENT OF HANDPUMPS IN THAILAND

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INTRODUCTION

The Royal Thai Government (RTG), in response to the International Drinking Water Supply and Sanitation Decade (IDWSSD) of the United Nations, has declared the Thailand Decade (1981-1991) with objectives corresponding to those of IDWSSD.

The master plan is focusing on specific policies, targets and action programs for the provision of water supply and excreta disposal facilities to the rural communities where the need for these basic services has been identified to be particularly extensive.

The policy relating to provision of clean water to rural areas in Thailand was initiated in 1964. In the following year, the cabinet appointed an executive committee for this matter, consisting of the members from various departments; responsibilities included planning and executing the National Rural Water Supply Programme. The target of the programme was and is to implement a plan to supply clean water to local inhabitants in some 50,000 villages throughout the country, by employing several means, including:

1. Rainwater collection tanks/jars;
2. Shallow dug wells and jet wells equipped with handpumps;
3. Small-diameter wells equipped with handpumps;
4. Deep wells equipped with handpumps;
5. Piped water supply;
6. Standard ponds;
7. Improvement of existing ponds;
8. Dikes and reservoirs.

In order to achieve the objectives of the rural water supply and sanitation program, two-part intervention strategies are proposed. The first part deals with policy-making and concerns the information system and integrated plan/master plan for all relevant agencies. The second part is for administration and implementation, and encompasses the following aspects:

- Health education and information dissemination;
- Primary health care (PHC) program;
- Manpower development;
- Revolving funds;
- Private sector programs;
- Water quality control.

BACKGROUND

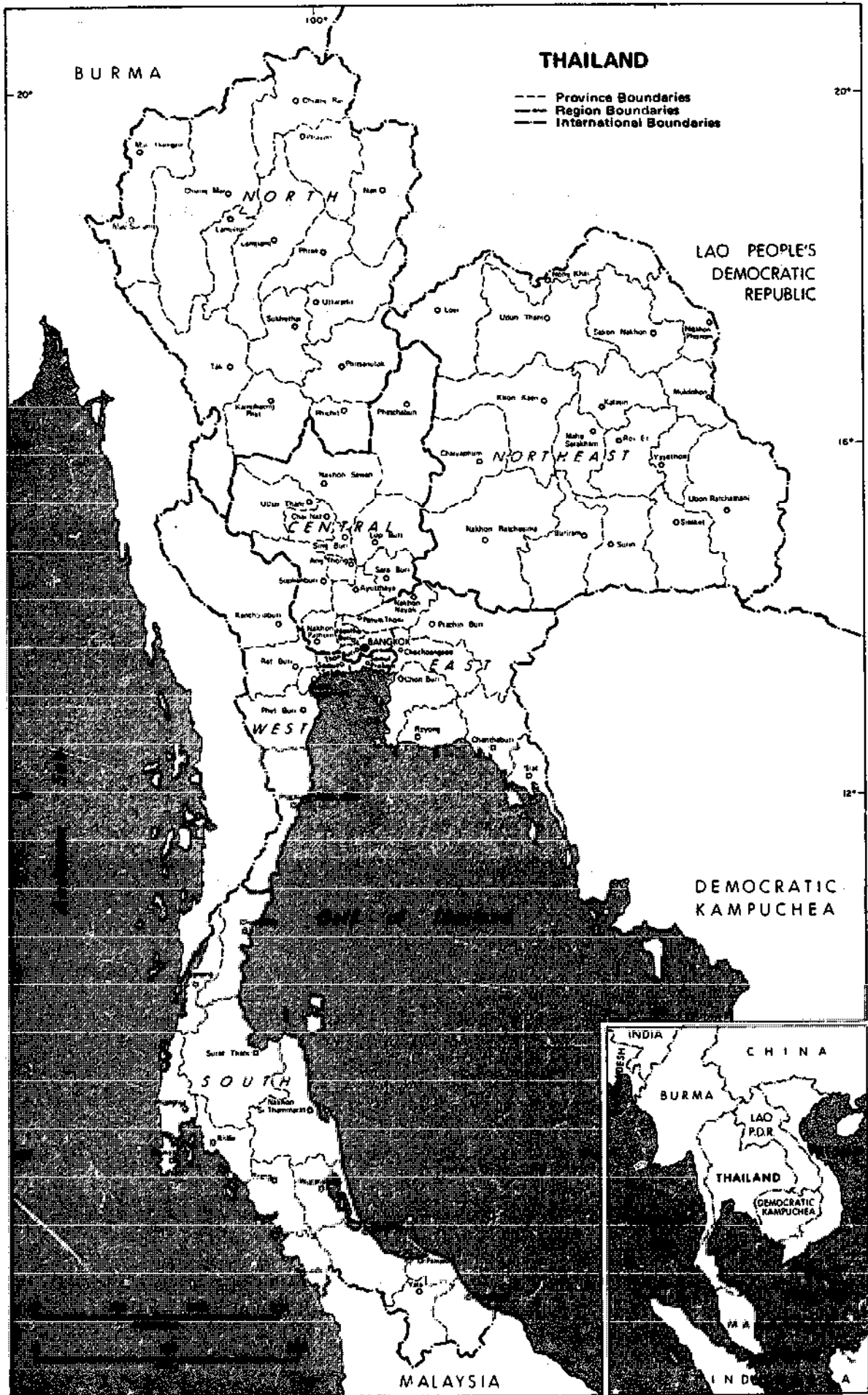
Thailand, formerly known as the Kingdom of Siam, lies in the central part of the Indochina peninsula of Southeast Asia and has an area of 514,000 km². The country is divided by natural barriers into four geographical regions with distinct economic, social and cultural characteristics, namely: Central, Northern, Northeastern and Southern. The terrain is generally flat, with scattered hills in the South and Northeast, and higher mountains in the North. There are 17 rivers with a combined length of over 100 km, the longest being the Mun with 673 km. Two main rivers flow from the north: the Chao Phraya River, which flows through the central part of the country to the Gulf of Thailand, and the Mekong River in the northeast, which forms part of the border between Thailand and Laos.

Generally speaking, rainfall in Thailand is good, benefiting agriculture with an annual mean of 1,550 mm, but in certain portions of the country, particularly the central part (especially west of the leeward side and along the southern part of the Tenneserim Ranges northeastern section), mean rainfall is somewhat meager in comparison to other localities. In certain years, rainfall may amount to 1,000 mm only. Relative humidity in Thailand is rather high (72.2-80.5 percent), and its seasonal variation is similar to that of rainfall.

The geologic formations of Thailand can be classified into two groups: porous rocks (alluvial deposits, younger terrace, older terrace and semi-porous) and jointed rocks (continental sedimentary, marine sedimentary, carbonate, metasediment and metamorphic, and granitic and volcanic). These two rock types comprise the most important aquifers of the country.

RURAL WATER SUPPLY

The delivery of small-scale rural water supply has been widely distributed among 15 government agencies who independently plan, implement and monitor their own programs. These agencies perform duties directly related to the provision of water for domestic consumption and are as follows: Provincial Water Works Authority (PWWA), Office of Accelerated Rural Development (ARD), Department of Local Administration (DOLA), Department of Public Works (DPW), Department of Community Development (DCD) and Department of Health (DOH).



Details of Achievement, Population Covered by Each Facility up to 1983

	Wells			Rain Storage Cisterns			Domestic Jar/ Water Filters	Piped Water Supply		Village Small Ponds	Supplementary Agricultural Water		
	Deep Wells	Shallow Wells	Tube Wells	150m ³ BPC Tanks	1.5m ³ Metal Tanks (400 gal)	3m ³ RPC or 5m ³ BPC		Rural Water Supply	Small Scale Water Supply		Standard Foods	Dredging Natural Fond/Swamp	Reservoirs Weirs, Dykes, Dams, Gate, Canal, etc.
1 DR	17871	-	-	-	-	-	-	-	-	-	-	-	-
2 IW	3540	-	-	-	-	-	-	-	-	-	-	-	-
3 ARD	6510	2465	-	-	-	-	-	-	-	-	826	296	472
4 DR-BMSD	3110	90	-	-	-	-	-	29	-	-	-	-	-
5 DR-SD	-	-	-	-	-	4487	2500	-	22756	-	-	-	-
6 IDLA	-	34347	20620	927	24825	-	-	-	-	-	-	6512	253
7 RD	-	2661	81	115	-	-	-	-	-	320	-	-	1480
8 RWMA	-	-	-	-	-	-	-	660	-	-	-	-	-
9 RD	-	-	-	-	-	-	-	-	-	-	-	-	2891
10 MSC	-	-	-	-	-	-	-	-	-	25	-	68	60
11 ED	-	-	-	-	-	-	-	-	-	-	-	-	1527
12 The Mobile Agric. Service Project	-	-	-	-	-	-	-	-	-	128	-	384	180
13 Rural Job Creation Projects	472	9564	-	-	-	3769	-	-	-	-	-	20597	18244
14 Rural Village Development Project (up to 1980)	-	241	-	25	-	-	-	-	-	-	-	-	73
Sub-total (by RTG)	31503	49358	20701	1067	24825	8256	2500	689	22756	473	826	27857	25180
Estimated Private Sector Activities <u>g/</u>	2972	7367	-	-	-	-	-	-	-	-	-	-	-
Total (Pub.+Pri.)	34475	56725	20701	←----- Total Rain Storage <u>b/</u> = 289,599 ----->				689	22756	473	826	27857	25180
% Functioning	85	60	45	80	75	80	80	25	75	70	85	100	100
No. of functioning Sources: RTG; (Pub.+Pri.)	26778 (29304)	29615 (34035)	9316 (9316)	854	18619	6604.8	2000	172	17067	331	702	27857	25180
				←----- (289599) ----->				(172)	(17067)	(331)	(702)	(27857)	(25180)
No. of household served facility	40	15	25	20	1	1	1	125	15	30	40	50	50
Population Served <u>c/</u> (x 10 ³)	5355.6 (5860.4)	2221.1 (2552.6)	1164.5 (1164.5)	85.4	93.1 (1448.0)	33	10	107.5 (107.5)	1280 (1280)	49.7 (49.7)	140.4 (140.6)	6964.3 (6964.3)	6295 (6295)
% Population Served: RTG; (Pub.+Pri.)	14.37 (15.72)	5.96 (6.85)	3.12 (3.12)	0.23	0.25 (3.88)	0.09	0.03	0.29 (0.29)	3.43 (3.43)	0.13 (0.13)	0.38	18.68 (35.9 (18.68))	16.89 (16.89)

Total population in 1983 = 37,277,000 people, so by the end of 1983, 27,607,300 and (29,937,000) people served by RTG and (Pub. + Priv.) are 73.98% and 80.31%, respectively.

Note: a/ ARD Isom Survey, Private: Public Shallow Wells = 1:6.7, Private: Public Deep Wells = 1:10.6 (See Appendix L, M)

b/ Storage Cisterns, Jar and Domestic Filters for all Public and Private parts are surveyed yearly by DRH-SD. Each of the functioning facility is estimated to be of 3 m³ capacity which can serve 1 household/facility.

c/ 5.0 people/household.

There are also other agencies involved in the provision of clean water for the rural areas, but their inputs are relatively small. Handpumps utilized by these agencies are of different prototypes. The five types of handpumps which are widely used are the Mineral Resource Department Handpump, Public Works Department Handpump, Health Department Handpump (Korat Handpump), ARD Handpump, and Local Administration Department Handpump. The Mineral Resources Department Handpump and the Public Works Department Handpump are the same prototype and the Health Department, ARD and Local Administration Department Handpumps are all the Korat Handpumps. Details of these handpump types will be given.

PROBLEM IDENTIFICATION OF HANDPUMPS

At present, about 52,000 deep-well handpumps have been installed all over the country by the government agencies mentioned previously. Based on the random sampling survey conducted by NIDA, it is estimated that 15 percent of the handpumps are out of operation on any given day.

As a result of these inoperative handpumps, the ability to supply clean water to all rural communities is lost. Moreover, a great number of wells have been constructed with community participation--in cash, in kind or both. Hence, villagers may view the loss of service as evidence that their contribution was a poor investment and lose their regard for the operating agencies.

The major problems which have been identified as the causes of handpump failures can be summarized as follows:

- (1) Too many different types of handpumps are installed in rural communities. This results in maintenance difficulties for local authorities and villagers, as certain spare parts of these pumps are not interchangeable.
- (2) Handpumps are not durable enough, due to poor design.
- (3) Product quality is not adequate, due to poor manufacturing quality control.
- (4) Community participation in maintaining handpumps is generally lacking.
- (5) Some agencies have no maintenance units and facilities of their own for maintaining the installed pumps. Although maintenance units are available at other agencies, their capabilities are insufficient for servicing all the handpumps which are in operation.
- (6) There is no effective coordination of handpump maintenance programmes among operating agencies at the grass-roots level.
- (7) Most handpumps are installed in remote areas which are far from the responsible agencies, thereby making it difficult for the communities to communicate with the agencies when maintenance problems occur.

- (8) Handpumps are presently not properly installed. Insufficient care results in several defects and subsequent damage to the pumps.
- (9) The budget allocated to each agency for operating preventive maintenance programmes is limited and inadequate.
- (10) Spare parts are not available in provincial and local markets due to a shortage of spare-parts manufacturers.

In summary, the failure of handpumps in the country is generally caused by poor handpump design, lack of effective maintenance strategies, lack of maintenance organization at grass-roots levels, financial constraints, and shortage of spare-part manufacturers.

In order to solve the problems mentioned above, the Rural Water Supply Division of the Department of Health will improve the handpumps themselves and improve or reorganize the management systems among the villagers by setting up a revolving fund for them.

The specific objectives for improving handpump technology are summarized as follows:

- (1) To study actual usage patterns of water obtained from deep-well handpumps;
- (2) To study performance and maintenance problems and damages of various types of handpumps being used in Thailand under actual field conditions;
- (3) To improve installation, operation, maintenance, and repair techniques for each existing handpump;
- (4) To evaluate types of material used for the different types of the existing handpumps and to compare their costs;
- (5) To establish guidelines for handpump maintenance; and
- (6) To incorporate the following characteristics into the handpump design and operation: (i) ability to withstand vigorous operation, (ii) ease of operation, (iii) consistent performance with a considerable degree of durability, (iv) local maintenance, (v) low investment cost, and (vi) versatility of use.

THE HANDPUMP SITUATION

As mentioned above, those government agencies are also involved in the drilling and installation of at least 4,000 handpumps a year in the rural areas. To date, they have installed more than 52,000 handpumps for deep wells, i.e., below 20 metres. It can be concluded that there are only two types of deep-well handpumps used in the country: one is a modified Dempster Pump and the second is the Korat Handpump. These two pump types are different only in the major part of the body; the lower parts are almost the same in

principle and may be able to use the same spare parts. The Division of Rural Water Supply wishes to improve these two types of handpumps so that the same parts can be used for repair and maintenance. As the Government's first objective, the ideal handpump can be modified to use most of the spare parts of the two major handpumps; the second objective is to obtain only one deep-well handpump model in Thailand.

Based on the above-mentioned plan, the Korat modified 608-C and the PVC deep-well pump are being developed and monitored for future mass production.

The Korat 608-C Modified Deep-Well Handpump is a very simple design: only change the gear handle from the Korat 608-A1 to the chain; most parts are the same. The cost of construction, operation and maintenance are reduced, and the performance of the 608-C is better, because the stroke length is longer and more water is provided per stroke of pumping.

The PVC Deep-Well Handpump has been developed for the major purpose of reducing the construction cost of the well, the cost of the PVC pump itself and the maintenance cost. The development program of the PVC handpump is divided into three phases:

Phase I--to study and modify the existing PVC suction-type handpump for use in a dug well with water levels not exceeding 6 metres below the ground level;

Phase II--to develop a PVC discharge-type handpump suitable for a deep dug wells;

Phase III--to develop a PVC discharge-type handpump suitable for a small diameter tubewell by using PVC well casing as the pump cylinder.

The project has finished Phases I and II and is proceeding to the monitoring program. Phase III of the project is the field tests. The suitable material and drilling techniques are being developed.

Some information and data on the major handpumps are attached with this report.

SOURCES OF INFORMATION

ARD (1978): Improvement of Handpump Design in Thailand, published under the sponsorship of UNICEF.

AIT (1984): Master Plan for Rural Water Supply and Sanitation in Thailand, submitted by Regional Research and Development Center, AIT

- CU (1981): The Development of a PVC Handpump, submitted to the World Health Organization by the Faculty of Engineering, Chulalongkorn University.
- NESDB (1978): Evaluation of Rural Water Supply Projects in Thailand, published by the Rural Water Supply Planning Subcommittee National Economic and Social Development Board in Cooperation of UNICEF.

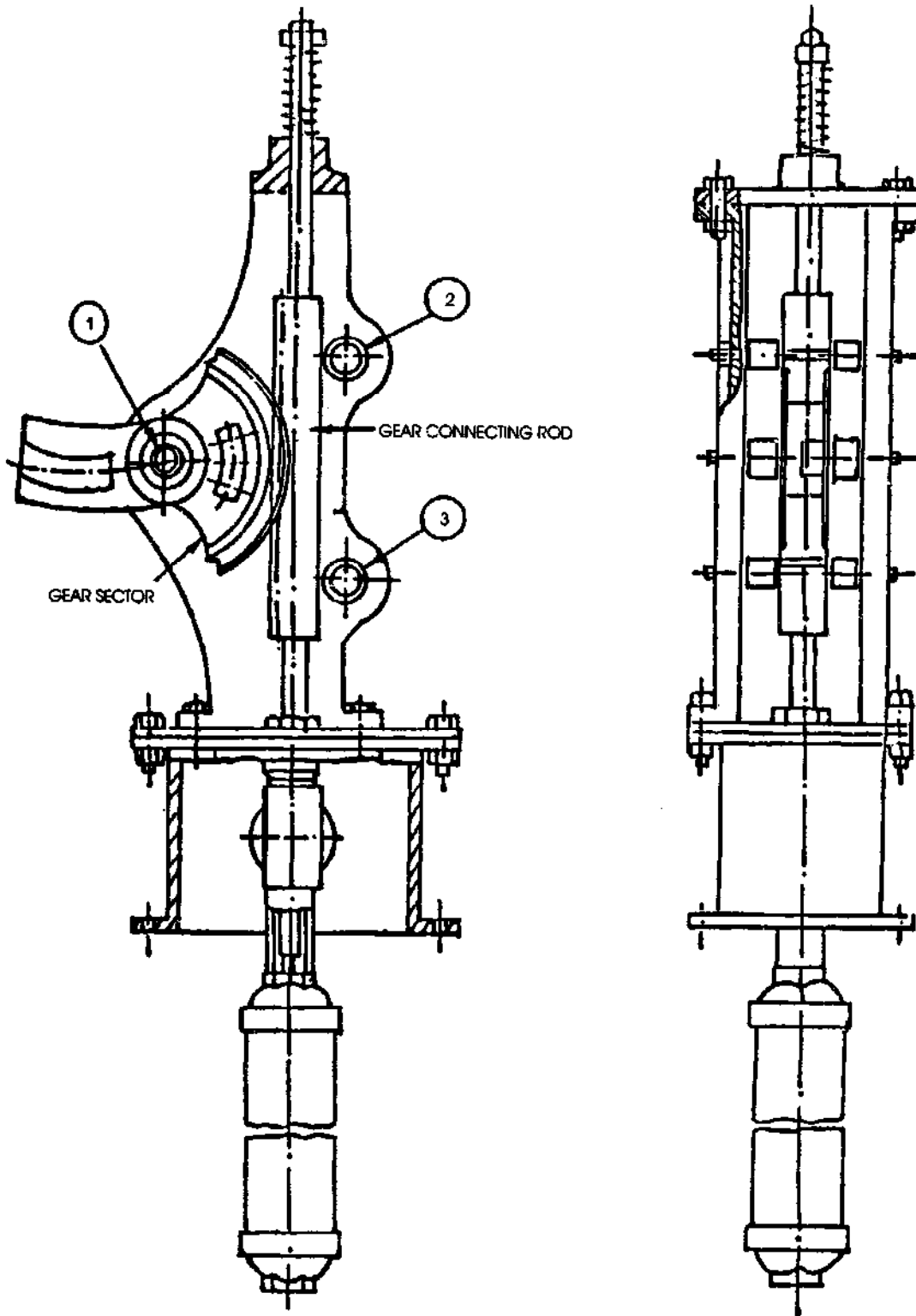


FIGURE 1 KORAT 608-A HANDPUMP

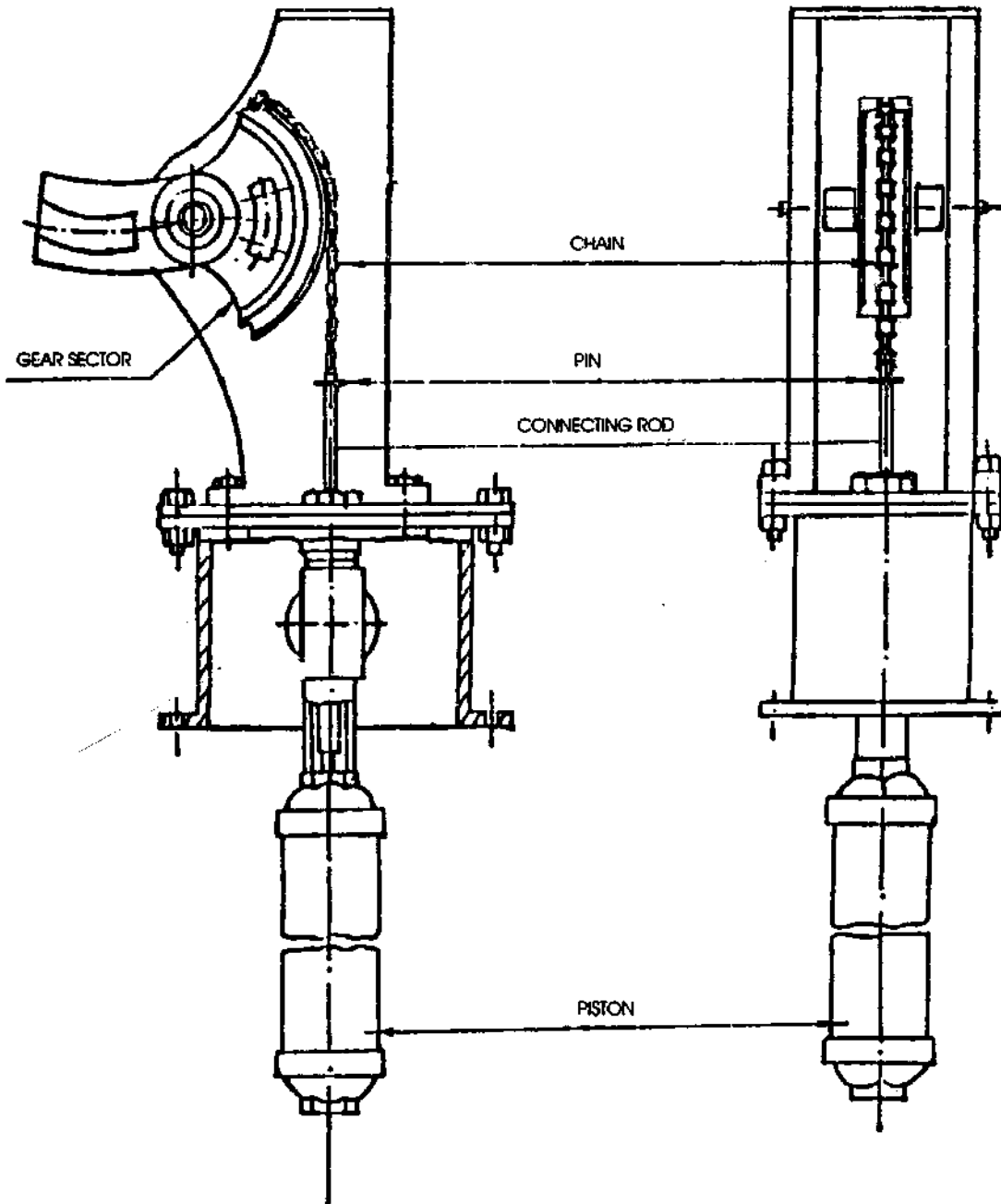


FIGURE 2 KORAT 608-C HANDPUMP

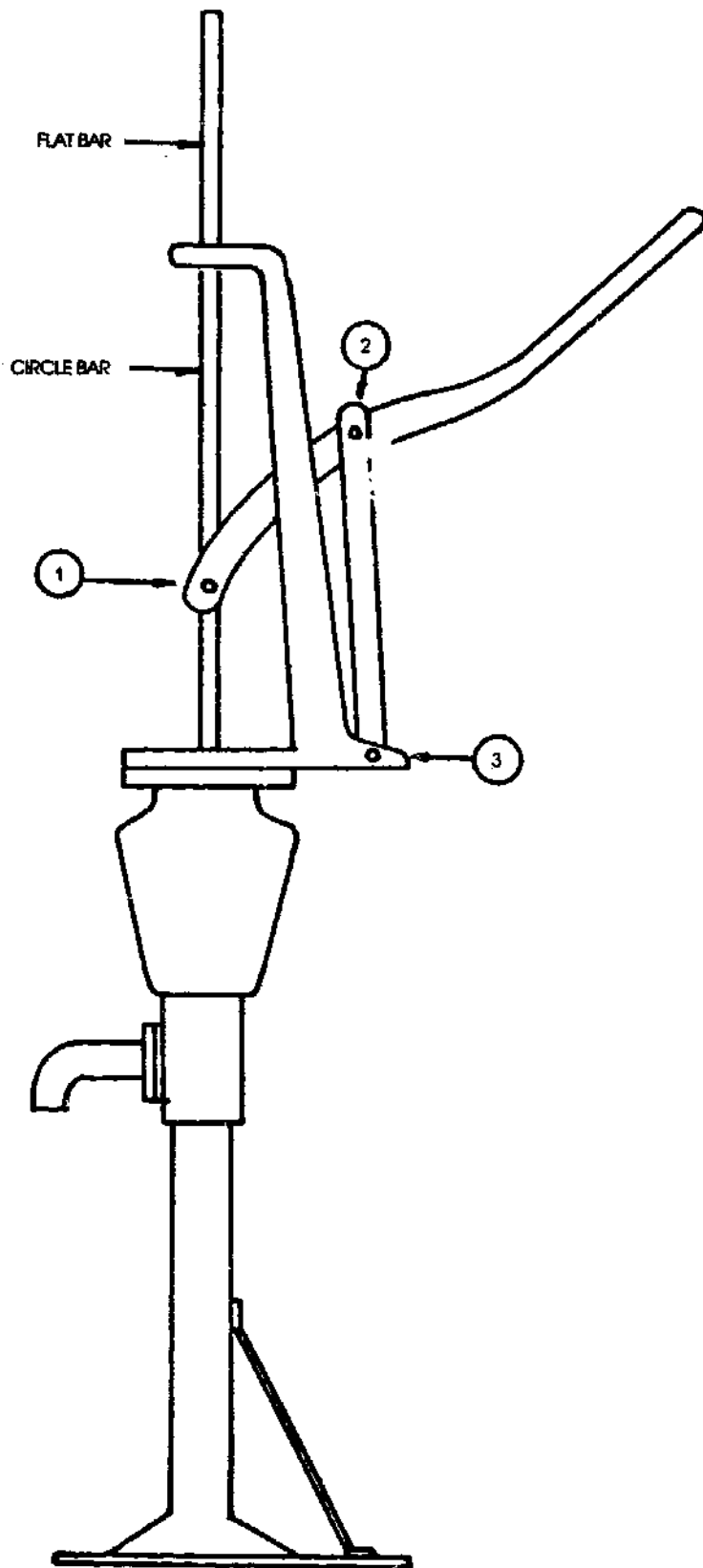
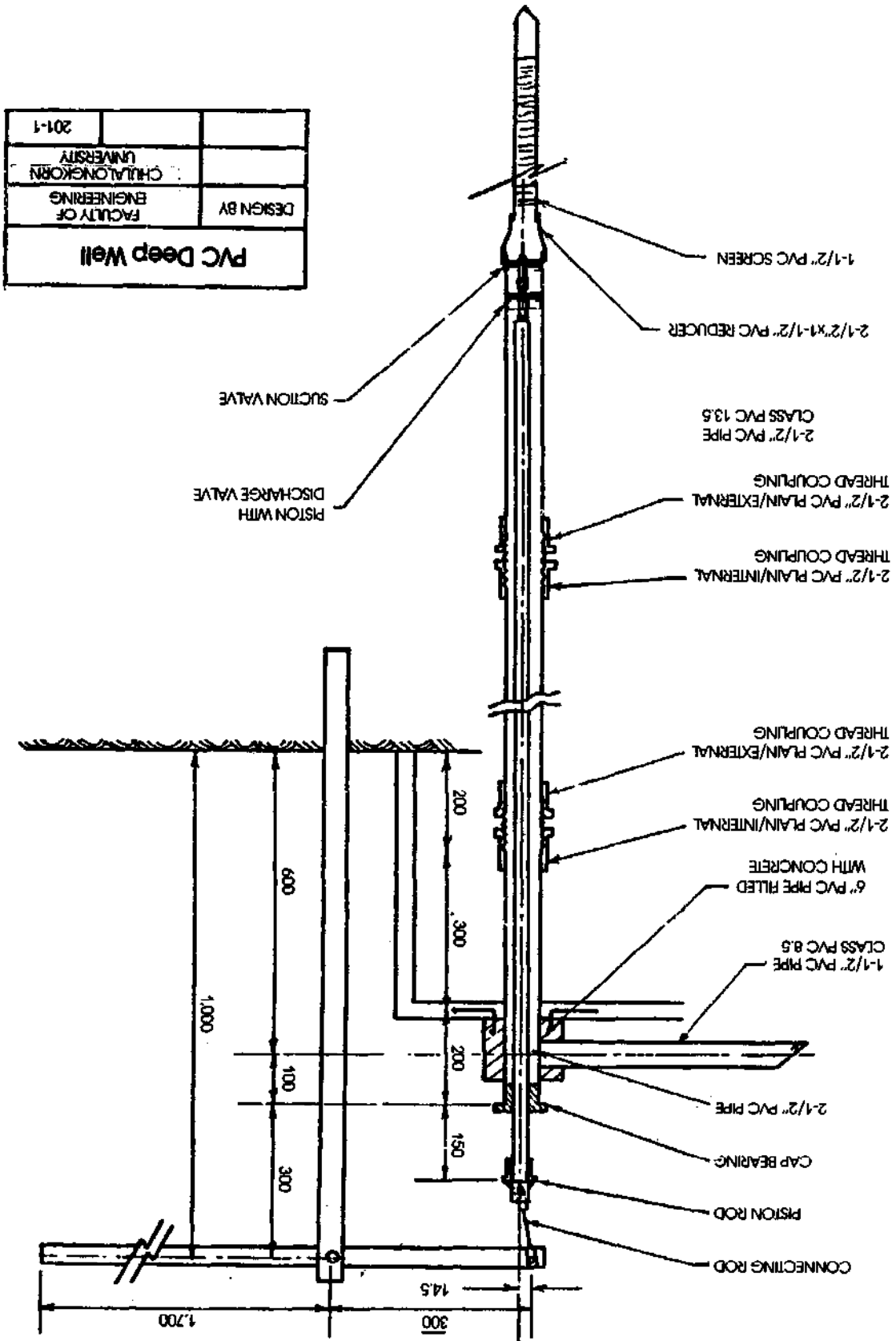


FIGURE 3 DMR HANDPUMP (MODIFIED DEMPSTER PUMP)

FIGURE 4 PVC DEEP-WELL HANDPUMP DESIGN



PVC Deep Well		DESIGN BY	
FACULTY OF ENGINEERING			
CHULALONGKORN UNIVERSITY			
201-1			

Table 1: Handpump Operations

Village Name	Daily User				No. of User/Day			Distance (metre)			Operating Strokes			Average Quantity of water (litre)
	Female		Male		Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	
	Child.	Adult	Child.	Adult										
NHONG KUNG KEE KUANG	42.00	82.38	11.14	7.52	143	184	83	205	400	-	5,170	6,637	2,287	5,170
KOK SOONG	0.74	14.30	0.09	2.78	18	27	6	103	400	-	2,229	3,950	796	1,205
JODE YAI	10.46	13.21	1.90	4.00	30	119	5	214	400	-	2,103	11,365	446	1,137
NHONG SAUW	24.71	89.79	9.79	28.13	152	189	54	204	673	-	8,955	10,904	3,350	4,592
LAUW NA DEE	28.12	72.88	8.08	8.32	117	168	80	272	1,000	-	6,559	9,048	4,411	4,685
PIA PHARN	37.67	68.62	4.33	7.76	118	181	30	134	280	-	10,266	13,084	2,058	7,333
NON MUANG	23.53	37.78	8.99	6.70	77	143	18	133	300	-	2,601	3,445	1,212	1,561
NON SOM BOON (UD)	5.03	15.59	1.00	7.90	30	49	18	115	300	-	1,686	2,547	995	911
SAVANG VA BEE	14.17	35.00	1.50	1.67	52	106	13	201	500	-	3,789	7,088	690	1,943
DAENG NOI	11.26	40.52	1.30	5.44	59	90	15	131	300	-	5,144	14,163	336	5,144
HIN LARD	35.23	69.82	5.77	14.55	125	209	37	82	225	-	5,685	9,943	1,700	4,061
HUEY JODE	19.79	10.89	1.18	2.86	35	75	17	150	300	-	3,693	7,739	1,772	1,996
BAN KHENG	2.77	13.43	2.40	7.43	26	35	10	91	240	-	3,042	4,709	972	3,042
BAN KAMIN	14.11	16.63	6.05	1.74	39	65	22	203	800	-	1,794	2,829	972	1,281
HUEY SANOOK	0.78	1.00	0.83	3.74	6	9	2	26	100	-	547	1,433	107	281
NON SOM BOON (KK)	16.83	17.00	3.75	2.13	40	68	18	50	200	-	3,752	6,868	1,566	1,924
SA PAN TONG	25.29	84.24	4.14	6.10	170	157	52	114	200	-	5,000	8,785	1,123	3,000
DONG CHANG	2.81	1.58	8.50	9.00	22	28	8	200	250	-	1,293	3,001	329	776
HUA NA KUM	15.15	24.68	5.15	3.53	49	114	9	260	800	-	1,275	2,991	232	1,275
Percent	26.29%	56.43%	6.83%	10.45%										
	82.72%		17.28%											

Table 2

Water Utilization

Number of Village: 19

Number of Families: 2,401

Water resources	Quantity of water used per day in litres					Total %
	Rain	Shallow well	Deep well	Others	Total	
Use of water						
Portable	77.5	4,150.0	1,922.0	330.0	6,479.5	12.39
Bath	12.0	1,946.5	9,141.0	671.5	11,771.0	22.50
Washing	4.0	1,805.5	5,886.5	408.0	8,104.0	15.49
Animals	-	2,524.0	5,268.0	1,708.5	9,500.0	18.16
Plant	-	5,503.0	3,166.5	7,788.5	16,458.0	31.46
Total	93.5	15,929.0	25,384.0	10,906.5	52,313.0	100.00

Table 3

Handpump Performance

Type of Hand Pump	Discharge litre/min	Operating stroke (times)	Diameter of cylinge (inch)	stroke length (inch)	Price US\$	Number of Parts	Discharge litre/stroke	Maintenance Cost year/pump US\$	Remark
Korat 608-A1	30.0	37	3	4	150	89	0.541	50	O&M by Villager
Korat 608-C (Mod)	39.2	20	3	6	130	86	0.936	30	
Demster Mod. DMR.	40.0	20	3	6	150	85	1.000	125	O&M by Agencies
Demster Mod. PWD	33.3	28	3	6	150	85	0.714	125	
PVC Deep Well	23.0*	40	2 1/2	4-8*	80	46	-**	-**	*up to length of fulcum ** Under developing Data not available

Table 4

Comparison of the Korat 608-A1 and the Korat 608-C
Based on Operating Ages of Handpumps

Parts	Operating Age, month	
	Korat 608-A1	Korat 608-C
1. Body	12	12
2. Handle gear/chain	12	12
3. Gear/chain connecting rod	6	12
4. Connecting rod	6	12
5. Top connecting rod	6	12
6. Stuffing box plate	12	12
7. Pump base	12	12
8. Spring up/bottom	3	10
9. Bush	6	12
10. Stud	6	12
11. Cover	12	12
12. Handle gear/chain roller	12	12
13. Pipe (up to water quality) & pipe coping	10	10
14. Cylinder	6	8
15. Top and low cap	12	12
16. Plunger	12	12
17. Poppet Valve	12	12
18. Piston	12	12
19. Spring cover	12	12
20. Spring	6	12
21. Piston seal	3	10
22. Ball bearing	8	12

SECTION 4

SUPPORT ACTIVITIES OF SELECT BILATERAL AGENCIES

CIDA ACTIVITIES CONCERNING HANDPUMP APPLICATIONS IN
RURAL WATER SUPPLY SYSTEMS

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All persons working in the rural water supply and sanitation sector in developing countries have much to learn from the development experience of China. Two years ago Canada and China initiated a bilateral program which focuses on technical cooperation/technology transfer through training and technical assistance in the fields of agriculture, energy, forestry and human resources development. My colleagues on CIDA's China Desk have worked closely with their Chinese counterparts to establish a foundation for fruitful technical cooperation in the future.

I would now like to present background on Canadian Development Cooperation.

Canada gives a high priority to international development. All of the elected political parties in the Canadian Parliament have announced their support for continued expansion of the aid program in the coming years.

The Canadian International Development Agency (CIDA) is the Canadian Government institution responsible for channeling most Canadian development assistance to developing countries. Our emphasis is concentrated on the poorest countries and reflects, as much as possible, a comprehensive, integrated approach to development, embracing the various available overseas development assistance (ODA) transfer mechanisms. CIDA aims for flexible programs to respond to the changing requirements of developing countries; its major sectors of concentration are agriculture, energy and human resource development.

CIDA has at its disposal a variety of channels for its programs. These include:

- (a) support to multilateral institutions, including the UN Agencies, the World Bank, the Regional Development Banks, Commonwealth and Francophone organizations and international research institutions;
- (b) direct assistance to developing countries on a bilateral basis (the primary channel for Canadian ODA); Canada provides bilateral assistance to numerous countries in Asia, Francophone Africa, Anglophone Africa, the Caribbean and Latin America, although the great majority of Canadian bilateral ODA is directed towards 30 designated countries (or program units, such as the Sahel);
- (c) Special Development Assistance, which provides financial support through a number of different programs to Canadian and international NGOs, cooperatives, trade unions, universities, colleges,

professional institutions and Canadian firms for the establishment or expansion of cooperative business ventures in developing countries; and

- (d) the provision of food aid, directly through the bilateral channels or indirectly through international development institutions such as the World Food Program.

Canadian ODA is also channeled to developing countries through the International Development Research Centre (IDRC) and Petro Canada International Assistance Corporation.

I would like at this point to make a few comments about CIDA's involvement in the water sector and in particular our experience with the UNDP/IBRD programmes in support of the Water Decade.

The provision of water for consumption, irrigation and industrial use is one of the most important issues facing mankind. Not only are developing countries concerned about ensuring that their populations have access to clean water, but many industrialized countries are also now realizing the importance of ensuring continued availability of water in their own countries for future generations. Only a few months ago, Canadian and American experts held a conference to discuss the future of the Great Lakes (which together account for a significant proportion of the world's fresh water). North Americans have always assumed that the vast water resources available to them have been (almost) a birthright. With the threats of pollution and consumption steadily reducing water resources in North America, scientists and, most importantly, parts of the public at large are becoming increasingly aware that future prospects (with respect to the availability of drinking water and water for industrial use) look dim if we proceed with measures of the past.

Certainly, the water problems facing the industrial world and the developing countries are different. The point I would like to emphasize, however, is that we are all (and most importantly the public in the industrialized countries) increasing our understanding of the importance of water for our future existence

CIDA has supported water and water-related projects for many years. We have financed many hydro-initiatives (based on our belief that the development of renewable energy sources should be encouraged), irrigation and drainage schemes, and handpump testing and sanitation projects. By 1982, CIDA had provided over the years more than US\$350M in financial support to water-related projects through the bilateral and special assistance channels, in addition to providing strong support for multilateral water projects.

Two examples of water projects CIDA has supported on a bilateral basis are as follows:

- (1) A US\$7.5M (approx.) project in Ethiopia--the Southern Region Water Resources Development Project--has provided improved drinking water to about 200,000 rural people mainly through the development of springs and the provision of drilled and hand-dug wells. The

project also involved setting up a regional administrative office and conducting the field research necessary to produce a five-year development plan for water resources in the Southern Region.

- (2) A water supply project in Mali (CIDA contribution of approximately US\$3.5M) involves the provision of potable water for over 30,000 villagers and the creation of a water quality control service at the Bamako Regional Centre. To date, it appears that the water supply systems are self-sufficient, both in terms of repair and cost: users pay a small fee at the tap for their drinking water and do their washing with well water. An observable drop in enteritis, diarrhoea, intestinal worms, dysentery and typhoid indicate an overall improvement in health, and the women are employing the time previously spent in the search for water on income-producing activities.

An example of an interesting initiative funded by CIDA in the field of new technology is found in CIDA's commitment of US\$11M (approx.) to the development and testing of photovoltaic (solar energy) water pumps as part of the US\$35M (approx.) Canadian commitment to development of renewable energy in the Third World. Phase I involves the testing of systems in Canada through Canada's National Research Council (at a cost of about US\$3.5M). Selected systems will then be installed in isolated regions in Mali, Niger, Senegal, Upper Volta, Rwanda and Guinea. These countries, currently suffering from severe drought, have had to rely on expensive diesel oil and fuel pumping systems. It is hoped that the development of economical solar-powered pumps will increase access to the water so critical to survival in this region.

I would at this point like to turn to some of the water-related activities CIDA has supported through Non-Governmental Organizations (NGOs).

In February 1984, CIDA had committed US\$14M (approx.) to supporting ongoing NGO projects in the water sector. Projects involve irrigation, water storage, well digging, dam construction, rural water supply, rainwater catchment systems and integrated rural development programs with water supply components. NGOs supported include UNICEF, Canada; CARE, Indonesia (through CARE, Canada); Club 2/3 Inc.; the Rotary Club; and the Canadian Catholic Organization for Development and Peace.

One of the major NGOs active in the water sector is the Canadian UNICEF Committee. CIDA is supporting a US\$1.2M (approx.) rural water supply project in the Irrawaddy Delta of Burma with a US\$250,000 grant to UNICEF: 2,000 handpumps will be serving 200,000 people, and 62,000 latrines will respond to the needs of approximately 300,000 people. In this region, the main cause of death and illness of small children is diarrhoea, which is caused by drinking contaminated water. There is also a high incidence of communicable diseases, particularly malaria, which afflicts persons of all ages. Burma has identified the elimination of diarrhoeal disease as a matter of first priority in its program with UNICEF; local communities are providing labour for construction and nominating representatives for training in the new technologies.

Other UNICEF Projects supported by CIDA include rural water supply in Ghana; provision of potable water supply in an arid rural area in Jordan,

involving 16 communities (approximately US\$1.0M); provision of piped potable water for almost 50,000 people in four impoverished remote provinces in Papua New Guinea (costing almost US\$50,000); provision of over 2,500 composting latrines for the neglected Atlantic coast of Nicaragua (at a cost of almost US\$150,000); and the provision of water supply and sanitation for 55 villages in northeastern Somalia (approx. US\$1.5M).

CIDA has recently provided support to the UNDP Global Interregional Projects Division in its efforts to address the goals of the Water Decade. CIDA has been one of the donors involved in the UNDP/IBRD Global Interregional Information and Training Program in Low-Cost Water Supply and Sanitation. This program aims at promoting low-cost alternative technologies and providing information and training to assist in their implementation. The material produced by the project team (which includes manuals, slide/sound shows, training modules, project preparation handbooks, case studies, films and brochures, etc.) is directed towards three different groups, namely, decision-makers, water sector specialists, and community animators (users). The first phase of the program (i.e., the production of materials and development of dissemination strategies) is projected to cost approximately US\$2M and should be completed in late 1984. CIDA has contributed approximately US\$550,000 to the Phase I budget. Phase II, the actual dissemination of materials produced in Phase I, is scheduled to begin in 1985.

CIDA is also supporting the UNDP/IBRD Integrated Resource Recovery Project in Cote d'Ivoire and India. Although smaller amounts of funding are involved, this project has the potential to result in significant advances in the field of biogas.

The third project CIDA is supporting through the UNDP/IBRD is the Handpumps Testing Project. CIDA is supporting testing activities in Bangladesh, Cote d'Ivoire, Ghana and Sri Lanka. Project activities in all four countries differ from each other. In spite of the complexities of the endeavours undertaken in Bangladesh, Cote d'Ivoire and Ghana, we look forward to completion of this project, as we believe it has the potential to advance our knowledge of handpump technology for a wide variety of circumstances. CIDA has provided direct financial support of approximately US\$1.4M to this project.

In the following, I would like to present a bit of the history of the Ghana Project as background to the current testing activities of the World Bank Project Team.

The CIDA-funded Upper Region Water Program in Ghana is about ten years old. During that time, several changes have been made to meet changing conditions and to incorporate increased village involvement.

Throughout the Upper East and Upper West Regions of Ghana, there have been more than 2,500 boreholes with handpumps installed to provide water to the rural population.

On average, approximately 80 percent of the handpumps are operating at all times. The cost of the program (as of 1983), including the cost of pumps, all vehicles, spare parts, fuel and lubricants, and salaries (including a cost for the expatriate staff) has been estimated to be less than US\$200 (approx.)

per year. The organization which maintains the pumps was first introduced during the Upper Region Water Supply Project (URWSP), a bilateral aid project administered jointly by the Ghana Water and Sewerage Corporation (GWSC) and CIDA.

The project, which ran from November, 1973-1980:

- drilled 2,500 boreholes, fitted them with handpumps and expanded the existing Ghanaian organization to maintain them;
- built a new Regional Workshop and expanded existing District facilities;
- improved the urban water supply systems in 3 centres;
- drilled and capped boreholes for future mechanization in communities of 1,500 people;
- trained Ghanaian staff.

This project was at the leading edge of Canada and other OECD donors' experiences with rural water supply in developing countries. We have all learned a great deal as a result of the first five years of experience. The Water Utilization Project (initiated in 1978) sought to use that experience to support a number of changes in the basic project methodology and the activities funded.

The changes were in the following areas:

1. use and choice of technology, e.g., (a) in the back-up systems, we have moved towards more appropriate technology, from the use of trucks and large repair crews to the use of motorcycles and village pump repairmen. This has allowed for economies in maintenance costs and lessened problems in the "maintenance of maintenance" (motor bikes are easier to repair than trucks); (b) in the the pumps themselves as a result of improvements in the technology and their local "repairability";
2. movement from central responsibility towards village responsibility, in particular in preventive maintenance, but also in health care and other elements of community life. This has meant training of and more reliance upon village pump men and community health care workers in the community, resulting in community labour for spin-off projects in small-scale irrigation, etc.

In March, 1978, the Water Utilization Project (WUP), was inaugurated. Project activities were designed to help people maximize the benefits of water obtained from the boreholes:

- In Site Development, efforts were concentrated on setting up village water user committees and selection and training of pump caretakers in carrying out preventive maintenance and minor repairs to handpumps. Self-help projects were undertaken in the construction of access roads, extended pads and animal watering troughs;

- In Community Education, villagers were taught about the hygienic use of water and the practices necessary to improve village sanitation:
- In Community Development, villagers were helped to carry out development projects of their own choosing which complement the water supply project, e.g., particularly pit latrine construction.

In 1984, Phase II of the Water Utilization Program was scheduled to begin, with efforts being directed towards site development and community education, although simple latrine construction will also be continued.

At the end of 1982, a third project, the Upper Region Maintenance Stabilization Project commenced. Its goal was to increase the operational reliability of water supplies in the Region by:

- replacing the original 1,200 handpumps installed under the original project with improved models;
- providing some vehicles, equipment and spare parts in an effort to improve Ghana's ability to maintain and stabilize existing systems;
- providing additional training to Ghanaian staff.

All three have contributed to the handpump maintenance program, actually developed in 1974-1975 and implemented during 1975-1977. From then until 1980, refinements were made to accommodate changing needs. Between the end of the URWSP and the present, the Water Utilization Project staff became involved and have assisted in keeping the program running.

Pilot projects have been carried out in two districts to study the possibility of merging WUP and handpump maintenance activities. A plan for completing the merger of the WUP Site Development Program and the Handpump Maintenance Program across the Region was completed in the latter half of 1983. This plan is currently being implemented and is expected to be completed in 1986.

Under the terms of the plan, a new Rural Water Supply Unit is to be set up under the supervision of each District Site Development Supervisor (or Site Development Advisor if there is no Supervisor). The unit is to include the former maintenance staff (extension mechanics riding motorcycles and service truck crews) and WUP Site Development Staff (extension motorists using motorcycles and masons and labourers using pick-up trucks). Staff will be involved in all aspects of rural water supply: pump and site maintenance, pump repair, access road construction and pad backfilling. One of the key benefits of this merger is expected to be the increased reliance on village labour to repair handpumps, lessening the reliance on the more expensive service truck approach.

CIDA and Ghanaian authorities believe that the Ghana Rural Water Supply Program is still evolving, the merger of the Water Utilization Program Site Development and the Handpump Maintenance Units having been recently

inaugurated. The performance history to date has been good. An eight-year average of about 80 percent for all handpumps in operation is worthy of praise and reflects the dedication and quality of the Ghanaian staff over the years.

The World Bank is testing two of the handpumps installed under the Upper Region program. CIDA is looking forward to the test results and trusts that further improvements in handpumps technology will be possible as a direct result of the efforts of the Bank.

I would like to conclude with one final point. We all recognize the importance of ensuring an adequate supply of potable water. We are also all aware of the potential difficulties facing us in terms of future water supply. It is clear that population growth alone will double water requirements in nearly half of the world by the year 2000 and that, coupled with increasing deforestation in much of the developing world, will make water supplies increasingly erratic. CIDA is pleased to be supporting activities in the water sector and is most particularly supportive of the handpumps testing project. Let us hope that the efforts of the many organizations and individuals involved in water supply and sanitation will help ensure adequate potable water for future generations.

WATER SUPPLY AND SANITATION IN DEVELOPING COUNTRIES
AND THE RESPECTIVE DEVELOPMENT POLICY OF THE
FEDERAL REPUBLIC OF GERMANY

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As a member of the German Ministry for Economic Cooperation (BMZ), I would like to tell you how we judge the water supply and sanitation situation in developing countries; what main sectoral guidelines have been laid down for the promotion of projects in this field; the reasons why the development of handpumps for use in the Third World is being promoted; and, in particular, why cooperation between the World Bank and the Chinese Academy of Agricultural Mechanisation Sciences is receiving support directly from the Federal Republic of Germany.

In another paper in this volume, Dr. Eyiers from the German Agency for Technical Cooperation (GTZ) deals with the technical details of the state of development of suitable handpumps both in the Federal Republic of Germany and with the collaboration of our experts in the Third World.

The GTZ, on behalf of the Federal Ministry for Economic Cooperation, implements technical cooperation projects jointly with partners in the developing countries. The Kreditanstalt für Wiederaufbau (KfW, the German Reconstruction Loan Board) is responsible for implementing projects of financial cooperation.

The provision of safe water, especially for health reasons, is one of the most important basic human needs. The Federal German Government has set the suprasectoral target of meeting basic needs within its Policy for Development and Cooperation, i.e., food, drinking water, health care, housing, clothing and education. Therefore, it promotes measures in these fields with special effort. However, although the the Government caters to basic needs and has a direct impact on health and performance, the appropriate priority has yet to be accorded to water supply, and, in particular, the necessary complementary sanitary measures in the development process of many developing countries.

It is necessary to mention that according to estimates of the World Health Organisation (WHO), only 73 percent of urban populations and 32 percent of rural populations in developing countries had access to safe drinking water at the beginning of the 1980s, and only 53 percent of urban populations and 15 percent of rural populations had adequate sanitation facilities. Some experts even consider these data to be overestimations.

This extremely unsatisfactory state of affairs is normally demonstrated by the following circumstances:

- Town centres and privileged residential areas are usually equipped with water supply systems, even if the water quality is often inadequate. Frequently, they have been equipped with such systems during the last two decades with external support. The urban problem zones and rural areas, however, often cannot obtain minimal support to improve their drinking water supplies and to promote sanitation facilities.
- Since only a part of the population in developing countries has access to hygienically safe drinking water, the others are forced to use unsuitable, often heavily polluted, and contaminated water for drinking.
- The health hazards to a large number of people from the absence of complementary sanitation measures (liquid and solid waste disposal; hygiene education) frequently become apparent only some time after the water supply improvements. We all know that even today the often disastrous effects of these health hazards are largely underestimated both by the people concerned and by the decision-makers. Moreover, the activities of the executing agencies and health authorities responsible for water and sanitation projects are frequently not sufficiently coordinated, and curative health measures receive usually higher priority than preventive measures.

Summarized, it may be said that about 2 billion people in the world--about one-third of the total population of this globe--live without a sufficient supply of hygienically acceptable drinking water and complementary sanitation measures. About 80 percent of all diseases in the developing countries are "water-related", of which a significant proportion is attributable to inadequate drinking water supplies and sanitation installations and to the absence of hygiene education.

It has been estimated that to provide all these people with good water--assuming a minimum quantity of 30 liters per head per day--and with minimum sanitation measures would require an amount of some US\$500 to 600 billion. This estimate is more or less realistic if conventional modern technologies continue to be applied. However, even using low-cost adapted technologies, about US\$300 billion would be necessary. That means about US\$30 billion would have to be raised in each year of the International Drinking Water Supply and Sanitation Decade, declared by the United Nations for the years 1981-1990.

About US\$6 billion of this amount should have been financed annually by external support. In reality "only" US\$2.175 billion were provided in 1981 from external sources, while the developing countries themselves raised the equivalent of an estimated US\$5 - 8 billion. Altogether, this is less than a third of what would be necessary.

I have confronted you with these astronomic, almost inconceivable, and by no means complete figures to show you how hopeless it is to try to solve the problem with the methods which have been applied thus far.

Since they cannot be expected to increase in the years ahead, currently available funds must be used more effectively in order to bring about a significant improvement in water supply and sanitation. Among other measures,

It is therefore necessary to ensure that the people play a larger part in the planning, construction, operation and maintenance of the projects in order to avoid losses by unsuitable, unadopted measures.

For economic as well as technical reasons, it is necessary to apply technologies that are as simple and effective as possible and appropriate to the situation in the respective developing country and project region and to reduce sophisticated technical standards. This means simply that the per capita amount necessary for the installation of supply facilities has to be decreased in order to increase the number of people supplied with the same amount of money available annually.

The Federal Republic of Germany has, in the past 25 years, provided altogether more than 100 billion Deutsche marks in official development funds for cooperation with the Third World. About 80 billion Deutsche marks of this amount has been committed for bilateral technical assistance, soft loans and financial aid for its partners in Africa, Asia and Latin America. Of this total, about 3 percent (about 2.5 billion Deutsche marks) were used for measures in the field of water supply and sanitation. Since the beginning of the "Decade" this percentage has been increased by 50 percent to 4.5 percent.

Although this increase in the share of water supply and sanitation measures within German development cooperation as a whole is a step in the right direction, it can certainly not yet be termed satisfactory and in proportion with the priorities of the developing countries. More important for future cooperation will probably be the recent decision of the Federal Ministry for Economic Cooperation to give priority to the support of simple water supply and sanitation measures, especially where the need is most urgent in the urban problem zones and rural areas. This important aspect is an essential point in the BMZ's new Sector Policy Paper on the "Promotion of Water Supply and Sanitation Measures in the Countries of the Third World".

Furthermore, this paper stipulates that supply standards and total project costs should be appropriate to the local situation and to the economic capacity of the project region in order to enable as many people as possible to benefit from the scarce resources. For these reasons, it is absolutely necessary that existing and alternative individual supply and sanitation standards be taken into account, along with the traditional water use habits of the population, in order to ensure acceptance of those future facilities by the people. Project design should provide for staged improvements so that the population can benefit immediately from low-cost initial measures and be given an incentive to actively support each subsequent improvement.

The principle of maximum simplicity in the design of water supply projects is of particular importance in rural areas, not only for cost-saving but also because of the special difficulties of ensuring the proper operation and maintenance of the facilities. This implies--depending upon the local conditions--the construction of rain water cisterns, of spring water catchments with gravity lines into the supply area or of simple dug wells or drilled wells--equipped with easy-to-maintain handpumps. Motor-driven pumps should be used only in exceptional and justified cases, not only because of their higher operating and maintenance costs (usually representing foreign exchange requirements) but also, above all, for environmental protection and

resource safeguarding (for example, excessive grazing in the well catchment area or excessive use of ground water).

For traditional central supply systems, investment costs may often be higher than DM 1,000 per person supplied. This does not take into account the high operating costs in many cases. In the case of simple supply systems, e.g., the construction of wells equipped with handpumps, the costs may be lower than DM 100 per person. This means that with the same investment, it is possible to supply ten times as many people as were supplied before. It is a precondition that those affected as well as the decision-makers should agree to the technically simpler solution.

An important argument against simple supply with wells and handpumps is the unreliability of this type of system. Though the basic technology of a handpump has been well-known for several hundred years, its adaptation to the needs and situations in the various climatic, geological and sociocultural regions has not yet been satisfactorily obtained. The range of different available types is confusing and the maintenance requirements of a number of pumps are many. In water supply projects which the Federal German Government has been supporting for many years, various pumps have been used for test purposes--particularly in Africa. However, in a large project in West Africa --where several thousand wells were drilled and equipped with handpumps--it again appears that the entire project is in jeopardy as a result of the maintenance problems with pumps of European origin and the persistent lack of suitably qualified maintenance personnel.

When in 1982 the Government of China, the World Bank and UNDP began discussions on cooperation in laboratory and field testing of handpumps, the Federal German government expressed its interest in supporting the objectives of this "pilot project".

It was assumed that the experiments begun bilaterally to improve handpumps for developing countries could be continued more effectively in a joint project with various institutions and organizations.

The Federal Republic of Germany therefore participated in 1983 with 1.5 million DM for a laboratory and field testing programme of handpumps which was carried out by CAAMS.

The German contribution sets out to achieve two main aims from the point of view of development policy:

- It is intended to make available to China existing German know-how in the development of handpumps.
- Other Third World countries are to benefit from Chinese experience and advice with respect to improved new handpumps through this international project.

GTZ ACTIVITIES AND EXPERIENCE IN THE DECADE PROGRAMME

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It is a great honour for me to have the opportunity to participate in this workshop and present a statement on our thoughts, concepts and current work in water supply and sanitation projects. The GTZ, as the executive agency of the Government of the Federal Republic of Germany's bilateral technical cooperation policy, has sought to become involved intensively in all facets of the Decade programme. I should like to present a review, primarily historical in nature, to illustrate how we view the Decade and its targets and objectives. I will go on to briefly present our understanding of where the bottlenecks are in water supply and sanitation and how solutions and concepts can be designed and implemented, and to summarise our experience after the first four years of the Decade. Last, but not least, I will review our current activities in this sector, our interest in intensively participating in the adoption and implementation of the Decade targets, and what resource we can offer to the Decade activities.

IMPLEMENTING THE DECADE OBJECTIVES

For more than 25 years, the Government of the Federal Republic of Germany has been cooperating with Third World countries in the water supply and sanitation sector. Concepts and strategies have changed considerably over this period, specifically concerning problems of identifying and meeting demands, target groups, training, technology, cost recovery, and the operation and maintenance complex.

In 1977 IDWSSD, the "Decade", was declared for the period 1981 to 1990. The discussions in Mar del Plata showed that neither the donors nor the recipients--the developing countries--had available concepts or solutions for implementing the Decade objectives. Preparatory work started in 1978/79. The results of this have shown how far the organisations, countries and experts involved in the programme have improved their understanding of the specific features and complexity of the problems in this sector; the most important aspect was--and remains--not giving up in the face of high investment and large figures involved. We must seek manageable solutions and make possible their achievement, even if this requires a longer period than a decade.

It is general knowledge today that the majority of countries will not be able to reach the Decade goals by 1990. There have even been rumours that the Decade is going to fail. We do not believe this--on the contrary, we feel there is growing international understanding and commitment to the Decade programme. A number of realistic concepts and strategies have been worked out and are being applied in the fields of rural water supply, sanitation, training and national plans and policies. This is the result of close cooperation between international donor organisations such as the World Bank,

UNDP, UNICEF, and WHO; bilateral agencies, including the GTZ; NGOs; and an increasing number of developing countries. There is a realistic prospect of considerable progress by 1990 in the optimal use of existing resources. It may be that 2000 will finally see the results which were originally set as targets for the Decade. One of the instruments in this process is workshops such as the one in China.

COOPERATION WITH CHINA

In this context, there are great hopes for close cooperation with China. This is why we are here--as part of a mutual learning process at the end of which the experiences and concepts of our Chinese colleagues can be integrated into the international programme for the benefit of the people of China and many other countries. The Decade is a unique opportunity to mobilise these attempts and initiatives.

LESSONS OF DECADE PLANNING

Ten years ago, the GTZ was implementing conventional community water supply systems of relatively high technical standards in its technical cooperation projects. The same was happening in the sanitation sector. We have learned more since then, and participation in implementing the Decade programmes has changed our priorities.

The figures and magnitudes which came out of the Decade plans are well known and have already been mentioned. They are far beyond our possible reach. They have the following implications for a realistic approach to projects:

- a renaissance of simple technologies is needed in water supply and sanitation: handpumps, cisterns, septic tanks, pit latrines, hydraulic rams;
- complicated machinery, such as drilling rigs or machinery for pipe and filter production, has to be adapted for simple and cost-effective operation in rural areas;
- upgrading and training of technical and management personnel at all levels have high priority;
- emphasis is needed on health education for the people--and particularly the women as they are the most important people to support the family in the water, health and sanitation sectors;
- water supply programmes must include sanitation projects (sewage and waste disposal) and concepts for recovery of resources;
- there is a need for innovation in simple technical solutions and procedures which do not depend on the export capacity of the industrialised nations; these must be directed towards strengthening the capacity for self-help in developing countries, and must make maximum use of local resources and know-how;

- a strategy which makes possible cost recovery and self-sustaining sector programmes and projects is most important.

POLICY OBJECTIVES OF THE FEDERAL REPUBLIC OF GERMANY

The Government of the Federal Republic of Germany formulated its new objectives for the Decade concepts very clearly in a policy paper in 1984 on water supply and sanitation. The GTZ will, as the executing agency, be implementing this policy in the field of technical cooperation. The policy has as its objective the optimal use of limited resources and capacities. The magnitudes are based on the demands of populations and their capacity to handle, operate and maintain the installations and facilities. If this approach is shared by other countries and organisations, it is very important for all involved in the Decade programme to coordinate their efforts.

This strategy--a return to simple technical solutions using modern techniques--only seems a step back. In reality, it is a pragmatic and sensible strategy. Instead of creating monuments of limited use, it leads to progress and improved living conditions for millions of people in rural and urban-fringe areas, and not only for a small number of grant recipients. The purpose of the strategy is as follows:

- to use existing resources as efficiently as possible;
- to minimise foreign exchange costs in the investment budget;
- to mobilise the capacity of the recipients for optimal use;
- to secure their participation in a decision-making and planning process which is firmly related to their living conditions;
- to create a feeling of responsibility among them for results of their own efforts and the efforts of those cooperating with them;
- and to adopt a stepwise approach to targets which cannot be reached in the short term or which involve high costs.

EXPERIENCE AND RESULTS FROM THE INITIAL PHASE

The experience of the GTZ during the preparatory period and the first four years of the Decade can be summarised as follows:

- Many of the countries actively involved in the Decade have developed national strategies and priorities for economical water supply and sanitation programmes; the GTZ is cooperating with about 20 countries on establishing national programmes and strategies.
- A focal point is the creation of national organisations; these need support through training and professional advice. A possible

target, for example, is the formation of an "umbrella" organisation for the population involved organised on the village or community level.

- The manpower problems have to be solved by intensive training at all levels. The GTZ has prepared about 60 modules for staff training which can be offered in combination with other training institutions (CDG, Cefigre).
- Foreign currency for investment in water supply and sanitation installations should be reduced to a minimum. It must be supplemented by or minimised through labour inputs of the populations concerned (e.g. force account) and by use of local know-how and resources.
- Investments and installations have to be economically sound.
- The cost of operation and maintenance and of future rehabilitation and improvement should be borne, after a limited initial period, by the communities or groups of beneficiaries.
- Much of the equipment and spare parts should be locally produced: this involves strengthening local skills and manufacturing capabilities.
- Water supply programmes have to be complemented by hygiene education.
- It is advisable to investigate the health status of the population (target group) before starting project planning.
- Pilot schemes must show significant benefits to users in order to achieve acceptance by the various groups in the population. This is a primary condition for promoting the concept at a national level and for convincing potential users of the advantages. This is the best way of creating involvement and willingness to provide services, materials and even money as a self-help contribution.

Training

One of the crucial points on the critical path to success is human resources development. The GTZ concept consists of a package of ways and means:

- formal education (6-7 years) and postgraduate courses (1-2 years), both mostly abroad;
- technical and practical training of technicians, administrators, laboratory staff (2-3 years for medium level), locally or abroad;
- local vocational training or apprenticeships for skilled labourers (2-3 years);

- special courses (3-12 months) for skilled operators in handling new equipment and techniques;
- refresher courses of all kinds for all staff categories (some weeks every year);
- national, regional and international seminars and conferences for leading cadres (such as the Shanghai seminar in November 1984);
- establishment of (local or regional) training facilities to train instructors and teams and to provide upgrading and refresher courses; this means training in the local language within the trainees' familiar environment; a new pilot project of this kind is the joint advanced training programme in seven Central American countries in cooperation with the GTZ and other donors;
- availability or creation of appropriate training and training tools very close to the point of need, and as much as possible, on the job.

Handpump Projects in Bilateral Technical Cooperation Programmes

Currently, the GTZ is involved in some 60 water supply and sanitation projects in 30 countries, with an annual grant budget of about DM 40 million and a regional concentration on African countries. There are increasing attempts to link water supply with sewage and waste disposal measures and/or hygiene education. In addition, the GTZ has been commissioned by the Kingdom of Saudi Arabia to be the project executing agency for village water supply projects at the regional level in ten Sahelian and West African countries.

Where groundwater supply is chosen, installation of handpumps has top priority for urban-fringe areas, small towns, and rural centres or regions. The wells can be dug or drilled, shallow or deep. There is obviously a need to install VLOM pumps.

Since a number of the GTZ handpump projects are tied in with the UNDP-World Bank Global Handpump Project, details are available from World Bank publications. Handpumps are (or will be) installed in GTZ projects in Niger, the People's Republic of Congo, Zambia, Sri Lanka, the Central African Republic, Paraguay, and five countries in the Saudi-Sahel Project (in addition to Niger), namely Mali, Upper Volta, Chad, Gambia, and Guinea-Bissau.

There is also a most interesting and important technical cooperation project involving CAAMS (PRC), the World Bank and the GTZ on developing and testing low-lift and deep-well handpumps. This project will be at the centre of our workshop discussions.

Well Construction Costs

One point of interest is the cost of well construction in our projects. In Sri Lanka (30-35 m depth) and Paraguay (70-100 m depth), the average cost for six-inch wells has been DM 150-170 a meter. In Niger, where the majority of wells are dug wells (1.8 meters in diameter), average cost per meter has been five times as high, at about DM 750 a meter up to 45 m depth, to DM 830 a

meter up to 60 m depth. This shows that more emphasis may have to be given to drilled wells, even though the danger of contamination is much higher than with open dug wells. It became clear that there is a high demand for low-cost drilling equipment to be used in this context.

Participation

Experience in popular participation in these well and handpump programmes is still in the initial phase. Concepts for achieving active participation are difficult, and must be sensitive to and strongly reliant on local conditions. There was intensive cooperation with the village people in Niger during implementation of a long dug-well programme. In other countries, particularly Paraguay, the People's Republic of Congo, and Zambia, the start has been promising, and there are cautious attempts at community participation. The practice in Zambia involves the national (or regional) institution concluding contracts with the beneficiaries as a precondition for starting the work.

Training Materials

Last, but not least, the GTZ has developed a number of handbooks on the basis of training programmes implemented over the past ten years. These cover Sewage Disposal, Sewerage Construction, Drinking Water Technology, Water Analysis, and Traditional Water Purification. A booklet on Drinking Water Analysis for laboratory personnel will be published shortly. These handbooks are available in English, and in some cases also in French, and are, in our opinion, a useful and important contribution towards introducing appropriate and standardised water analysis and treatment techniques for application under the conditions of developing countries and their staff training needs.

SUMMARY

Summarising the GTZ's intermediate experience from the first phase of the Decade, a large number of new and comprehensive national and regional strategies and concepts have been developed. Projects have been identified or are under implementation. Conceptual adjustment and application of appropriate technologies are essential features of the programmes. There is, we believe, no reason for pessimism about the Decade.

FINNIDA ACTIVITIES CONCERNING HANDPUMP APPLICATIONS
IN RURAL WATER SUPPLY SYSTEMS

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GENERAL

The Government of Finland has assisted three countries in the development of their rural water sector. The oldest project is in Tanzania. The project started with a Feasibility Study in 1972, continued with a Water Master Plan, and has been in the Implementation Phase since 1978. Projects of similar types were started in Kenya and Sri Lanka in January 1982. All the projects include large surface and groundwater inventories, together with investigations and proposals for the development of the water supply, mainly for the rural areas. Projects have continued with implementation, including the drilling of deep boreholes, piped water schemes and handpump schemes.

Since the projects in Kenya and Sri Lanka are still in their early stages, the following paper concentrates on describing experiences gathered in Tanzania.

MTWARA-LINDI RURAL WATER SUPPLY PROJECT

Background

In Tanzania, the rural population primarily lives in villages, normally having 500 to 2,000 inhabitants. The village forms an economic unit which, in addition to private production, has some communal production. The funds acquired by the communal production of the village are then used for providing various services, like health and education facilities for the community.

Water supply is one of the services which are partly provided by the self-help efforts of the community. The project staff members, working within the field of rural water supply, are therefore adapting their activities so that the works of construction, operation and maintenance of the water supply systems are either partly or entirely the responsibility of the village. A functioning water supply scheme is then a result of cooperation between the rural community, a governmental organization and the donor agency. However, the operation and maintenance of a rural water supply scheme should be primarily the responsibility of the community, so that the degree of self-reliance is maximized and the dependence on outside assistance minimized. These targets are especially emphasized in the new local Government Act of 1982, which was put into effect in 1983.

Project History

The Government of Finland has assisted the Government of Tanzania in the development of the water sector in the Mtwara and Lindi Regions since 1972. The two regions, with a total area of 84,700 km² and a present population of about 1.25 million people, are among the least developed areas in Tanzania. Until now the following phases have been completed:

- Feasibility Study 1972-1973
- Housing Project 1973-1974
- Water Master Plan 1974-1977
- Implementation Phase I 1978-1980
- Implementation Phase II 1980-1981

Implementation Phase III was begun in January 1982 and will continue until the end of 1984.

HANDPUMP WELLS

Construction

After the Water Master Plan Report was completed, the Government of Finland agreed to finance the implementation of some rural water supply schemes which were included in the plan.

During Phase I, seven piped water supply systems serving about 130,000 people and 556 handpump wells serving about 110,000 people were constructed. A large training programme for Tanzanian staff was also carried out.

Implementation Phase II began immediately after Phase I in April 1980. During that phase, 620 handpump wells serving about 120,000 people were constructed, and the construction works of five new piped water supply systems were either started or completed. Training of well caretakers for handpump wells, training courses for foremen, and on-the-job training for separate working groups continued during Phase II.

The implementation of Phase III started at the beginning of 1982. By the end of 1982, 382 additional wells were constructed, the total number of wells constructed thus far being 1,558. About 1,000 wells are still needed to complete the handpump scheme. The target is to complete the scheme by the end of 1987. The handpumps will then serve about 500,000 people. At the beginning of 1984, the project received a down-the-hole hammer drilling rig. The rig will be used to drill medium-deep handpump wells, especially in the Kasasi and Nachingwea Districts, where dug wells or auger wells cannot utilize aquifers deeper in the basement rock, and many existing wells are getting dry at the end of the dry season.

The depth of dug wells varies from 3 to 5 m and that of auger wells from 7 to 11 m. The average pumping depth varies respectively from 2 to 3 m and

from 3 to 6 m. All the handpump wells are equipped with Finnish-made Mira pumps. One well serves about 200-250 people.

Village Participation

The villages are participating in the construction of handpump wells. The information on possible well sites is collected by interviewing the villagers during the survey. In machine-dug and auger-well production, the villagers provide labour assistance.

Since July 1983, no payments have been made to the village for providing the labour. Earlier, villagers were paid 500 TSHS per well after completion. The change has caused some problems, especially near those villages which have previously received payment. Hand-dug ring wells are constructed independently by villagers and the project provides only supervision (one foreman) and materials. After the construction has been completed, the whole responsibility for handpump maintenance is gradually handed over to the village.

The villagers are informed about the well construction in village meetings. The authorities of the district are involved, and division and ward secretaries participate in the meetings. Finally the agreement for the handing over of the wells to the village is made between the project and the village.

Costs

Ring wells dug by tractor excavator

Materials	9,000 TSHS (1 USD = 13 TSHS)
Local labour	250
Transport	2,750
Others (excavator, etc.)	1,500
Siting and supervision (incl. expatriate staff)	<u>6,000</u>
	19,500 TSHS

Ring wells dug by hand

Materials	9,000 TSHS
Local labour	350
Transport	2,700
Others (tools, etc.)	50
Siting and supervision (incl. expatriate staff)	<u>6,000</u>
	18,100 TSHS

Hand auger wells

Materials	5,200	TSHS
Local labour	550	
Transport	1,300	
Others (hand auger set, tools, etc.)	450	
Surveying	1,000	
Supervision (incl. expatriate staff)	5,500	
	<u>14,000</u>	TSHS

Medium deep boreholes (Aqua Drill)

(Estimate)		
Materials	12,000	TSHS
Local labour	800	
Transport	1,200	
Others (rig, tools, etc.)	2,000	
Surveying	7,000	
Supervision (incl. expatriate staff)	11,000	
	<u>34,000</u>	TSHS

All costs are as of January 1984. The costs of self-help labour and project overheads are not included.

Village-level operation and maintenance

During Phases I and II, two village well caretakers have been trained for each village where handpump wells have been completed. In practice, an average of one day of training has been insufficient, and mobile maintenance groups have done the main part of actual maintenance. Every well has been visited on an average of three times a year. With this degree of maintenance, 85-90 percent of the handpumps are always in working order.

During Phase III, a new training programme for the village-level maintenance system has been created. Those village caretakers who have already participated in the one-day training will be selected for retraining wherever possible.

The central person in the village-level maintenance system is the village well caretaker. Two caretakers are needed in every village served by shallow wells.

By the end of 1983, some 150 village well caretakers have been trained for 75 villages. Maintenance of 40 villages has been handed over to the village governments.

The total number of villages to be covered is estimated at 400. By the end of 1984, some 550 village well caretakers will be trained and some 270 villages handed over to the governments.

The second link in the handpump/well maintenance system is the district maintenance centre. These centres are points for spare-parts distribution; technical help for village well caretakers is also available there.

The regional maintenance centres of Mtwara and Lindi will coordinate the handpump well maintenance of the regions. The spare parts will be shipped to Mtwara and distributed to Lindi and on to district centres. The project will take care of the spare-parts distribution for the time being.

The project has established a follow-up system for those villages where the maintenance has been handed over. The villages are visited frequently, once every three months. The work of the village well caretakers is checked and followed up, and village governments are interviewed. The follow-up safaris made so far have shown that the average percentage of broken pumps is slightly higher than when the maintenance system was centralized. Many villages have some problems when starting the village-level maintenance. The purpose of follow-up work is also to encourage the villagers to organize themselves to give some additional training to village well caretakers and to give technical assistance when needed. Spare parts are not distributed during the follow-up safaris; the well caretakers are encouraged to collect them from the district centres.

Maintenance Costs

Owing to the recent launching of the village-level maintenance programme, the exact figures for the costs are not available. The maintenance costs mentioned below are calculated according to the centralized maintenance system carried out by the project.

Maintenance costs are calculated on the basis of direct costs only and do not include project overheads. In order to calculate the costs of spare parts, the number of used spare parts has been estimated from the last half of 1983, because previously, the information collected from maintenance cards included all the spare parts used, but did not take into consideration that, for instance, cylinders are repaired in the workshop and reused. The real consumption of cylinders is quite small, because more than 90 percent of all replaced cylinders can be repaired. In the case of other spare parts, it has been assumed that they are replaced with completely new parts. Actually, besides cylinders, some other spares can be repaired and recycled, but repair has been on such a small scale that it has had very little or no effect on the total costs.

Spare parts	257,700 TSHS	45%
Transport	200,000	35
Local labour	109,000	19
Tools, etc.	4,300	1
TOTAL	571,000 TSHS	100%

Maintenance costs/well (1150)	497 TSHS/well
Spare part cost/well	224 TSHS/well

DEVELOPMENT OF HANDPUMP TECHNOLOGY

Rural Water Supply Handpumps Project (INT/81/026)

In accordance with the contract between the Government of Finland and the World Bank, the INT/81/026 pump test began in March 1983. The aim of the project is to evaluate, compare, analyze and promote handpump technology. The project is monitored by a World Bank expert and is providing facilities for carrying out the research work. Since it is still in its early stages, results are not yet available. The following pumps (and later, possibly others) are being tested: Nira, Blair, Malawi, Afridev, SWN 81 and Kangaroo.

Development of Handpump Technology within the Project

The Project started experimental work with a new type of handpump late last year. This direct-action-type pump has been designed to be as simple as possible. It uses local skills and materials as much as possible. Excluding pipe wrenches used for drop pipes, only one spanner is needed for maintenance and repairs. The actual dismounting work can be done solely by removing one bolt. The cap can be opened, the inner pipe with wooden bushes can be taken away, and the piston rods can be lifted up along with the piston.

The pumps have been made by skilled local workers using mainly imported materials. The aim, however, is to use only locally available materials, so, for example, the bushes have been made of wood. According to the Dutch Morogoro Project, wood called mkarati is the best alternative, but our own experiments have shown that African blackwood (ebenhholz) is at least as long-lasting and is available in southern Tanzania. Three-month field tests have so far shown that the wearing of wooden bushes is rather fast during the first weeks, but after creating considerable clearance, the rate of wearing gets much slower.

Both two-inch and three-inch cylinders have been tested. Theoretically, the yield of the 3-inch cylinder is 2.25 times greater than the smaller ones, but it is also 2.25 times heavier. When the three-inch cylinders are used and the water level is less than four metres, all the participating villagers have agreed that the pump is heavy to use, but has a good yield; therefore, most users have been satisfied.

HANDPUMPS EXPERIENCES IN DUTCH DEVELOPMENT PROJECTS

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INTRODUCTION

During the past decade, the Netherlands has been actively involved in the field of rural water supply, with projects in Africa, Asia, and Latin America. About 100 projects are being executed with an average annual expenditure of 65 million US dollars.

Four major projects in which handpumps are installed began some years ago and are being executed in Indonesia, Tanzania, Guinea-Bissau and Burkina Faso. Three types of pumps were developed: the "Bandung" pump, the SWN pump, and the Volanta pump. In developing these pumps, the VLOM concept has been applied to varying degrees.

Experience has taught us that the eventual success of these projects mainly depends on the possibility of keeping the pumps operational. Initially, it was assumed that the government agencies responsible for water supply would take charge of the maintenance of the pumps, but as the situation developed, it has become apparent that the maintenance of large numbers of pumps was too much of a financial and organisational burden on the government and could not be sustained on a long-term basis.

If the government cannot assume responsibility, the village must. This new situation demanded a new approach to the design of the pump. Apart from being strong and reliable, it also must be easy to maintain on a village level in a situation where there are no skilled technicians and very few tools.

The "Bandung" Pump

In Indonesia, the Netherlands financed the development of a suction handpump for shallow-well application called the "Bandung" pump. This pump is mainly used to lift water from underground reservoirs fed by a distribution network. The principal aim has been to locally produce more reliable pumps than those presently being imported. The efforts have been successful and the "Bandung" pump is now locally produced in large quantities. It is mainly constructed from cast-iron parts, using scrap metal as a raw material. As the scrap metal varies in composition, it is difficult to guarantee the quality of

the cast iron. For this reason, a new version is presently being developed in which all cast iron parts have been substituted by parts made of mild steel. If this experiment works out satisfactorily, the mild steel may eventually replace all cast iron.

The SWN Pump

In Tanzania, the Netherlands finances a rural water supply programme which started in 1973. This programme operates in an area where the depth of water is such that suction pumps cannot operate. When the project started operation, little experience and knowledge was available about this type of rural water supply programme. As for the pumps, efforts were initially directed at improving the durability of the superstructure. This resulted in the development of the "Kangaroo" pump and, more recently, the SWN pump. The SWN pump is reasonably strong, reliable and highly efficient. Its superstructure can be locally manufactured, while the below-ground components, together with the raw materials, are imported. Local production has now reached the level of 50 pumps per month, supplying not only the Dutch projects, but others. As quite a number of pumps are sold outside the project, thought is being given to separating the production unit from the water project and giving it independent legal status. This may enable the pump production to continue after termination of the project.

The main constraint for future production will be the supply of raw materials. Potential buyers will have to either provide foreign currency in advance or supply the raw materials. A long-term solution for this problem has not yet been found.

Maintenance of the pumps has so far been assured by the project, but recently the need for village-level maintenance has been recognised. Plans are being worked out to establish a two-tier maintenance system in which a village caretaker assumes the daily preventive maintenance responsibility and a mechanic on the district level is called in for actual replacement of parts. This system is still in a preparatory phase and no conclusions as to its efficiency can now be drawn.

The Volanta Pump

The Dutch rural water supply programme in Burkina Faso started in 1980 and could thus benefit from experiences gained elsewhere. During the preparatory phase, before actual construction of wells began, a literature survey was done on existing types of handpumps, on actual performance in the field and on the different maintenance systems under which they functioned.

Two conclusions emerged from this survey--on one hand, certain requirements had to be met by a good handpump and, on the other hand, no pump existed meeting those requirements. It was then decided to design a new model pump, which eventually resulted in the Volanta. As the concept of this pump for use on deep aquifers is considered to be promising with regard to village-level maintenance, efficiency and durability, the remainder of this paper will be concerned with the different aspects of the Volanta pump.

THE DEVELOPMENT

Design Parameters

Based on the literature survey and field experiences, the reasons for prolonged breakdown periods of traditional models of deep-well handpumps could generally be defined as follows:

- Inability of users to extract the pump cylinder and replace worn parts, making them dependent on a central maintenance organisation;
- Lack of funds and organisational capacity for a central maintenance organisation to function efficiently;
- Lack of spare parts.

Apart from the difficulty of maintenance, many of these pumps functioned very well in terms of efficiency, durability and ease of operation. Thus, in establishing the design parameters for the Volanta pump, the positive characteristics of traditional handpumps were combined with ease of maintenance, possibility of local production and low recurrent costs.

Recurrent Costs

Low recurrent cost is a prerequisite when handpumps are to be maintained by the users. Recurrent costs consist of depreciation and repairs. Repair costs can be divided into transport, labour and spare parts, of which the transport cost is generally the highest.

In designing the Volanta, these costs were to be reduced by allowing the users to carry out repairs on the pump cylinder and eliminating the transport and labour components.

The depreciation is determined by investment cost and the length of the period during which the pump functions. Consequently, long service life has been a predominant design parameter.

The Construction

The most difficult obstacle proved to be to combining ease of maintenance of the pump cylinder with high efficiencies at different depths. A solution was found by producing a physical separation of the pump cylinder and the rising main, allowing the cylinder to be extracted from the well, while leaving the rising main in place. During operation of the pump, the cylinder fits in a conical seat attached to the lower end of the rising main. A simple piston and cylinder pumping principle could, therefore, be adopted offering high efficiency.

Sealing between the piston and cylinder is achieved by applying a long piston with a small clearance and providing sufficient hydraulic friction to act as a seal. Seals are the main components to be regularly replaced in conventional handpumps, as to wear results from mechanical friction.

To further simplify the operation of extracting the cylinder, the pump rods are interlocked instead of threaded, and the superstructure of the pump is situated beside and not on top of the borehole.

The pumpstand is a monolithic concrete block used to eliminate vibrations often observed with metal pumpstands. A flywheel drive was chosen, as it offers equal lead distribution and provides gradual accelerations and decelerations of the piston, thereby reducing shocks and vibrations. A rotating movement, as opposed to an oscillating movement, also gives longer life to bearings. A crank with adjustable stroke-setting allows the same piston diameter to be used effectively at different depths. All parts and bearings are heavily over-dimensioned, permitting abusive use to a certain extent.

In order to avoid the need of replacing parts due to corrosion, all below-ground components are made of stainless steel and synthetics. A filter has been introduced on the suction end of the pump cylinder to prevent particles larger than 0.1 mm from entering.

Testing and Fault Rectifications

The first pumps were installed in early 1981, and soon design faults became apparent. Three major problems were encountered:

- Breakage of the pump cable.
The first pumps were equipped with stainless steel cables instead of rods. These cables failed after a certain time due to fatigue. Simultaneously, they stretched under load, resulting in lower pump efficiencies at greater depths. The cables have been replaced by stainless steel rods and now function satisfactorily.
- Leakage of the rising main joints.
Threaded PVC pipe connections were not resistant against the dynamic loads imposed on them during pumping and fractured. Cemented joints have been introduced to eliminate this problem.
- Sandlocking of the pump.
Originally the cylinder was standing inside the rising main on a conical seat, which left an annual gap between the rising main and the cylinder. The water passing through the pump was less pure than expected, and small sand particles filled the annual gap, blocking the cylinder and rendering extraction impossible. Now the cylinder is suspended from the conical seat and hangs under the rising main, thereby eliminating the problem.

It took over two years for these modifications to be developed; meanwhile, a number of pumps were already installed. Many of them broke down because of these faults, causing considerable discontent. Simultaneously, the Volanta was tested by CATR in England, and the same faults emerged. This test will be repeated this year, and it is anticipated that the results will now be positive.

CAPACITY INCREASE THROUGH MOTORISATION AND STORAGE

Occasionally, handpumped water supply systems, originally designed to serve a certain population, become inadequate when the number of people increase. The capacity of the system is stretched by increasing the pumping time to a maximum of 24 hours a day. Such a situation is obviously not very favourable, as it requires people to spend an unproportionate amount of their time at the well waiting for their turn, and requiring them to spend the night there.

In such a case, three options are available: drilling a second well, installing a motor pump on the first well or motorising the existing handpump. The first alternative--drilling a second well--is the most expensive, but if equipped with a handpump, the well does not call for a higher level of maintenance or funding, or does not depend upon the availability of fuel as required by the second alternative.

The third alternative, motorising the existing handpump, requires the least investment and could well prove to be an interesting intermediate solution between handpumps and full-fledged motorpumps.

This possibility was borne in mind when fixing the principal dimensions of the Volanta and, as a result, the diameter of the flywheel is such that no reducing gear is necessary to drive the pump by means of a flat-belt transmission directly from any standard engine running at 1500 rpm. The fuel consumption in this case is about 0.25 l/hr. As the Volanta is equipped with a sealed pumphead, water can be forced to an elevated storage tank without requiring any modifications. An important advantage of this type of motorised pumping systems is the possibility of pumping by hand if, for any reason, the engine cannot be used.

BOREHOLE REGENERATION

Boreholes have a tendency to show a decrease in yield several years after they have been constructed. Eventually, this may even lead to a "dry hole". This decrease in yield is largely due to either a deposit of solid particles in the immediate surroundings of the well screen or a chemical reaction causing a growth of microbes which impede water passage to the well.

To minimise both this loss of yield and the risk of a "dry hole", it is generally recommended that the well be regenerated every five to ten years. Most handpumps require complete removal in order to gain access to the well for regeneration operations. The Volanta, because to its large-diameter rising main and off-set superstructure, can remain in place while only the pump cylinder and rods are removed. One method of regeneration is airlift pumping, causing alternatively high and low water velocities and reverse flows to clean the entrance to the well.

It seems equally possible to carry out chemical regeneration on a borehole with a Volanta pump. The chemicals are introduced in the rising main from the top, and subsequent extraction of the cylinder causes the water

in the rising main containing the chemicals to flush back through the screen. After a period of 24 hours, when the chemical process of dissolving the impediments has finished, pumping can recommence.

An additional advantage is that by removing the pump cylinder for inspection or repair, the contents of the rising main are discharged in the borehole, causing a short but vigorous backflush in the filter and screen. This in itself provides a periodic regeneration.

TRAINING

Training of the Installation Team

To install the Volanta, a team of three persons is advisable: a leader and two assistants. The person in charge should preferably have a background as a mechanic or a mason.

The most favourable scenario is for a water project to subcontract the installation of pumps to a small local contractor or free-lance technician. Knowledge of the pump and its installation therefore becomes available outside the project staff, contributing to maintenance in the post-project period.

The installation of the pump takes place in two phases. First, the concrete foundation is constructed, taking two to five hours, depending on the extra facilities, e.g., a drain pit, cattle-watering troughs, etc. Ten days later, the pump itself can be installed in about two hours.

Training the installation team takes three days--one day for theory and two days for practice. To provide theoretical training, a 120-picture slide series is available, showing step by step the construction of the concrete foundation and installation and dismantling of the pump. The practical training takes place in the field. On the first day, two concrete foundations are made in the presence of an instructor and the next day, two pumps are installed on the previously prepared foundations. Refresher courses seem superfluous, as the team will get sufficient practice; regular inspection of the installation will assure quality.

Training of the Village Committee

As the handpump is to be maintained by the community, it is logical that a committee be formed to handle the collection of money and to coordinate the necessary actions to ensure continuous operation of the water supply system. Such a committee generally consists of a chairman, a treasurer, some representatives of different groups and two or more repairmen. This committee as a whole must understand its responsibilities and the chairman and the treasurer should receive special training to prepare them for their duties. Such training is given by the project's extension workers and takes several days. It is not within the scope of this paper to elaborate on the details of this training.

Training of the Village Repairmen

After a Volanta pump has been installed, an extension worker employed by the project visits the village to give training to those members of the committee that have been selected to become "repairmen". This training takes about two hours. The future repairmen have to extract, dismantle and reassemble the pump cylinder three or four times, while the men, women and children stand around and watch. The advantage of this method is that not only the two trainees, but also many others, are given the opportunity to get acquainted with the operation.

As a teaching aid, there is an "owner's manual" provided with every pump, depicting with photographs the whole process of extracting, dismantling and reassembling the pump cylinder. The booklet also contains a spare-parts catalogue and a logbook. This manual is left with the chairman of the committee. If a problem arises with the pump that cannot be solved on the village level, the villagers have to call on external assistance--usually the one who has installed the pump.

One-time training cannot suffice because the interval between breakdowns may well be more than one year. Consequently, the opportunity for the repairmen to practice their newly acquired skills is not great. It may be advisable for this reason to instruct the villagers to dismantle the pump regularly for cleaning and inspecting the internal parts, but mainly for practicing the operation. Still, refresher courses are necessary and should be provided at increasing intervals during the first (approximately) five years after initial installation.

LOCAL PRODUCTION

Factories

The Volanta pump is actually in production in the Netherlands and in Burkina Faso. Backstopping of the local production is channeled through DGIS (Dutch Agency for International Cooperation). Interest in local manufacture has been expressed by other countries, but has thus far not led to any actual production.

Raw Materials

Raw materials in standard sizes for the Volanta pump can be obtained from any industrialised country through a "bill of materials" indicating the quantity, dimensions and specifications. This "bill of materials" is also available through DGIS. As delivery and transport time from Europe to Africa takes at least four months and another four months may be needed to manufacture and sell (approximately) a hundred pumps, a well-organised administration and sufficient amounts of money for financing are essential.

Manufacturing Techniques

The manufacturing techniques required to produce the Volanta pump are straightforward and can be found in any developing country. They include sawing, welding, turning, drilling and thread cutting. The cylinder is a

piece of standard fiberglass-reinforced polyester tube that does not require internal machining; the piston is made with a tolerance of 0.05 mm.

Jigs

In order to ensure that parts are correctly cut, drilled and welded, a set of jigs has been developed for most of these operations.

Quality Control

No special method of quality control has been applied yet in Burkina Faso. The use of jigs wherever possible already greatly reduces the risk of inaccuracies, but for certain operations such as turning, they cannot be used. It seems advisable to introduce the use of calibres to check the measures of the turned parts. The locally produced pumps in Burkina Faso have a guarantee for one year of operation. If parts fail within this period, they are replaced free of charge if the failure is due to bad workmanship and not other causes, e.g., an excess of sand in the water, a crooked borehole.

Import Taxes

Most developing countries have heavy taxes on imports. In Burkina Faso, for instance, an 85 percent tax has to be paid on steel and machine parts, but essential goods such as water pumps are exempted. This situation does not favour local production of pumps as, officially, the tax is paid on the raw materials, not on imported pumps. A definite solution for this problem has not yet been found, and for the moment the custom authorities make ad-hoc decisions for each new arrival. Perhaps a solution lies in pumps being manufactured by a government or parastatal organisation rather than a private company.

Legal Status

Initiating local production of handpumps in a developing country can be done within a governmental or parastatal organisation or a private enterprise. In Burkina Faso, it was decided to have the pump made by a private company run by a Catholic mission. It is therefore independent of the water project and is more flexible in management and financial transactions than a governmental or parastatal organisation. A disadvantage may well be the difficulties in obtaining import tax exemption in the future. The possibility of eventually transferring the production unit to a parastatal organisation should therefore not be excluded.

FIELD EXPERIENCE

Wear and Tear on the Pump

The first pumps were only installed in early 1981, so there is no real long-term experience as yet, especially since the first pumps were still equipped with cables, threaded rising mains and old-styled pump cylinders. Experience with stainless steel pump rods and cemented rising main joints dates only from early 1983. The new type of cylinder has been in use since

mid-1982. As for the superstructure, which has not yet been modified, wear thus far is negligible. No parts have needed replacement since 1981.

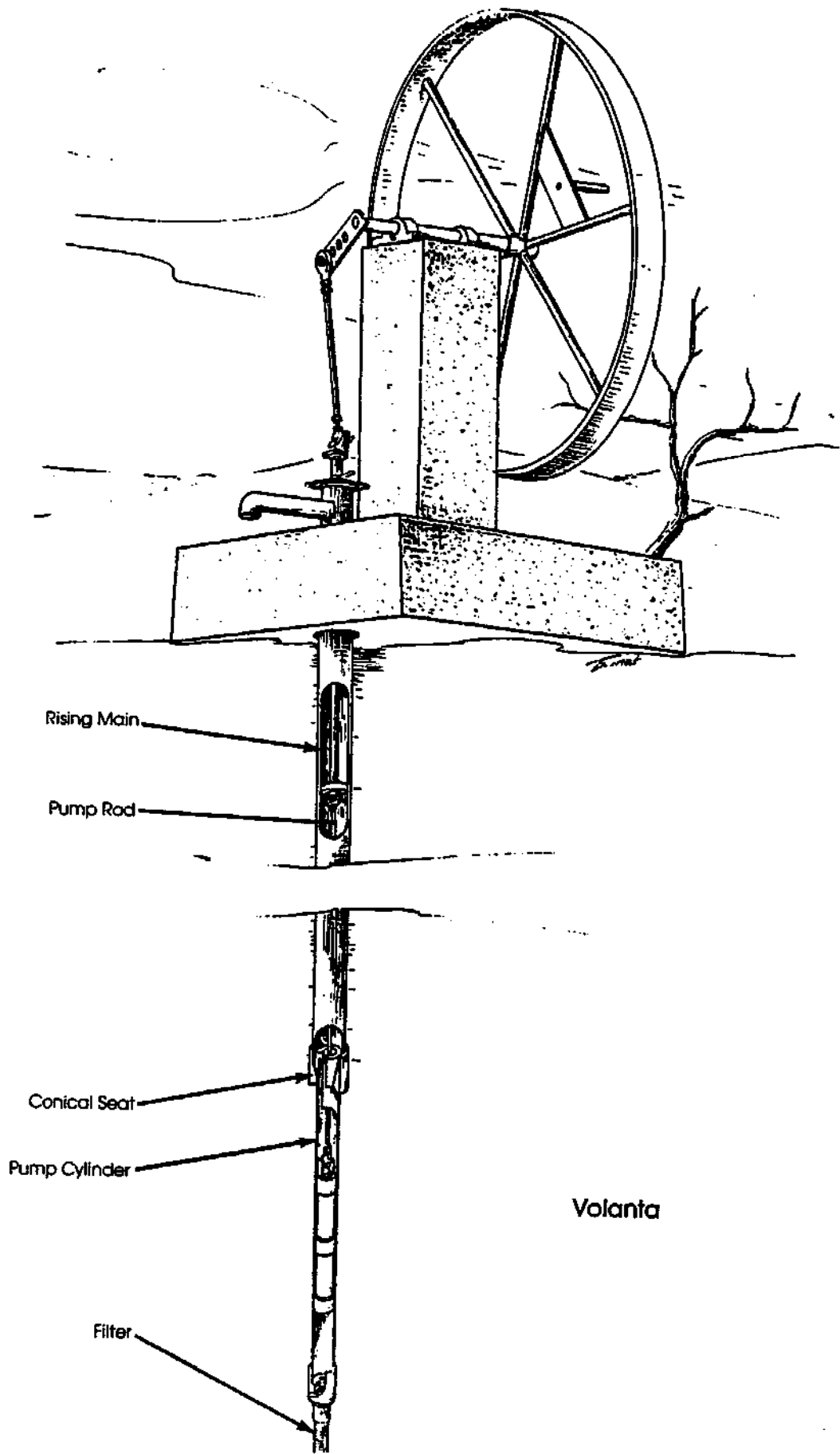
As for below-ground components, no significant wear has been found on the piston, cylinder, valves and seats. The cemented rising mains were found to leak in some instances, caused by the pump rods rubbing against the inner wall of the pipe. This rubbing in turn was caused by the borehole not being straight and forcing the rising main into a curve. Following this observation, it was decided to equip all pumps with guides on the pump rods. The pumps equipped with guides have not shown signs of wear on the rising main. The greatest depth of installation as of now has been 55 mm. It is expected that installation depths of up to 80 mm will not cause problems.

Quality of Installation Work

In Burkina Faso, two pump installation teams are operating, one employed by the water project and one working as a free lance contractor, mainly for the pump factory in Ouagadougou. Both received only the practical training described before, as the slide series was not yet ready at the time. The quality of the installations performed by the contractor is generally better than those performed by the project team. It appears that motivation plays a role equally important to training. Contractors who are paid per installation are more likely to be critical of their work than employees of a project.

Quality of the Village Repairmen

It is not easy to evaluate the extent to which the village repairmen have familiarised themselves with the pump, for until the end of 1983, pumps broke down because of broken cables and pipe connections, failures which cannot be repaired at the village level and which should not occur. For the pumps installed by the Dutch project, the village committee has been advised to remove the pump cylinder once a month for inspection and cleaning the filter; they usually do so. Naturally, there are always some committee members that are more enthusiastic than others, but given long-term supervision and support from the extension workers, it seems quite feasible that in the future they can all carry out repairs on the pump cylinder without external assistance.



HANDPUMP APPLICATIONS IN RURAL WATER SUPPLY PROGRAMMES
SUPPORTED BY SWEDEN

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INTRODUCTION

Programmes for rural water supply have been part of Swedish development cooperation since the mid-1960s. During the first ten years, large piped systems were primarily constructed. Little attention was paid to handpumps or other appropriate applications.

The numerous evaluations undertaken in the 1970s, however, revealed the magnitude of the global problem to be solved in the area of drinking water. Furthermore, the oil crisis, coupled with the basic needs programmes, the Habitat conference, the World Water Conference and the Drinking Water and Sanitation Decade preparations, helped to shape an awareness in the development circles of the need to move towards less complicated applications.

It has also been globally accepted that the development programmes must be based on the consumers' priorities and participation. The development of favourable attitudes in this direction has proven to be a long process both on the donor and receiver side. It requires change of attitude and approaches within the bureaucracy and in the objectives of the water programmes, and calls for better consumer organisation, especially in the mobilization of women, who, after all, are the ones who handle the water. More positive consumer attitudes are needed for the collective utilization of and responsibility for the water projects. To facilitate this, simplified techniques are called for. There is evidence that changes are taking place in this direction. It is, however, also evident that these changes are part of a long-term process which needs continuous back-up and attention.

SWEDISH STRATEGY FOR RURAL WATER SUPPLY AND SANITATION SUPPORT

Sweden issued its own strategy for development cooperation in the water sector in 1979, and a more general policy for rural development in 1980. These strategies are both based on the principles of local participation. The objectives of the water strategy are to support programmes and activities which are directed at improving the situation for the rural poor, in areas such as public health, by limiting the frequency of water-related diseases, reducing the distances to sources of water, improving water quality, and improving access to sanitary facilities. It is hoped that this will pave the way for socioeconomic developments in general.

The strategy identifies five main components:

- water supply;
- sanitation/protection of water source;
- water use/health and hygiene education;
- coordination of activities; and
- capacity-promoting activities.

In summary, the changes that have taken place from 1970 to 1980 are as follows:

<u>From</u>	<u>To</u>
High Technology	Low, appropriate technology;
No sanitation policy	Sanitation/protection of water source;
No health policy for water programmes	Water use/health, hygiene education;
Centrally planned and constructed water supply	Local participation;
Purely technical assistance	Involvement of social scientists in the sector;
Formal technical education	Human resources development and training at the project level.

Present Support

Substantial support is today given to integrated rural water supply and sanitation programmes in six countries: Angola, Botswana, Ethiopia, India, Kenya and Tanzania. The support is given at two levels: (1) to the central authorities for development of administrative and guiding functions; the national training programmes; and planning, budgeting, procurement, and reporting functions; (2) to the physical water development programme in a geographical area, i.e. to construction of water supplies and sanitary facilities and the infrastructure and training needed to operate and maintain the facilities. Rehabilitation of previously-built facilities and health/hygiene training are also part of the programme.

The main approach adopted in implementing these area programmes is one of organizing and encouraging the consumers to participate and assume responsibility for the facilities. In order to achieve that, however, applications which are easy to operate have become necessary. Handpumps have begun to play a major role in this endeavour. Swedish support to such programmes has changed radically since the 1970s, but much more remains to be done.

TECHNOLOGY ADAPTATION IN SWEDISH-SUPPORTED WATER PROGRAMMES

The rural water programmes supported by Sweden all have foreign currency problems and import restrictions. One aim therefore is to make the projects independent from imported equipment and fuel. Windmills, steam engines, hydraulic rams, photovoltaic solar projects and handpumps are being tried. Where possible, spring-capping and gravity systems are used. Local production of equipment and spare parts is also used to help fulfill this aim.

Handpumps

Handpumps are increasing in numbers and importance in the programmes. In Ethiopia, Tanzania and India, water supply from dug or drilled wells equipped with handpumps is given a high priority.

In Kenya, several donor-supported programmes include handpumps as part of the UNDP/IBRD global test programme. As handpumps have been regarded as an inferior technique when compared to other technologies used in Kenya, the project has developed slowly. Public acceptance and the declining economy have helped to change this attitude. The original test project is now developing into a full-scale handpump project covering one district.

In Botswana, handpumps play a minor role, due to the generally low water table and the methods of community settlements which are suitable for distribution systems to public stand posts. Attempts have been made to convert from diesel to coal-charged engines.

Different types of handpumps are being tested in all SIDA-supported country programmes. Pump types and modifications tested thus far are as follows:

- India Mark II, with different cylinders and seals;
- SWS-pumpen (Sholarpur Well Service---see appendix 1);
- Inalsa (Mark II modified for shallow wells);
- Robbins & Myers Moyno pump;
- Monopump;
- Consallen pump (with modification of over-ground structure);
- Two indigenous Ethiopian shallow-well pumps;
- Morogoro pump of Tanzania;
- Petro-pump.

The Petro-pump has been used in several countries. Weaknesses have been found at certain points. The pump has therefore been brought back to the workshop for adjustments and further testing.

A thorough evaluation of the above-mentioned tests is underway, but already it is evident that some of the pumps are superior to others. In the rural water supply programme in India, the India Mark II is now exclusively being installed. In Ethiopia, a slightly modified type of the Inalsa pump has performed well in shallow wells (less than 15 m). The indigenous Ethiopian pumps are also undergoing promising modifications.

Factors of Importance when Selecting Pumps and Sources

Sources of water for handpumps are shallow wells (less than 15 m) and boreholes of 20-50 m (occasionally down to 100 m).

Traditional sources, such as operating open wells, can be equipped with handpumps after being properly cleaned, lined and, if required, covered. In some cases, low-yielding wells are improved upon by drilling a borehole in the bottom of the well. New wells are lined with concrete rings. Where appropriate, they are constructed with subsurface dams in order to obtain a continuous flow of water.

Another commonly used method is the tubewell, i.e., a borehole with casings and screens. The hole diameter is normally 4 - 6". When the diameter is 5" or more, the plan is often to eventually replace the handpump with an engine or motor-driven pump. As the water yield is not proportional to the hole diameter, it may be more cost-effective to drill smaller diameter holes. Even a 3" hole would be sufficient, if only pumps can be found or developed to fit such holes.

Proper borehole construction and design has been found to be important to the good performance of the pump. To obtain full benefits, the design of the platform, sand trap, drainage and soak-pit is also essential. Control of the material before installation may pay off. Fencing the pump area may protect the pump and reduce risks of contamination of the water source. The location of the pump in the village has been found to be most important for providing equity usage, for avoiding vandalism and for obtaining the best use and care for the pump.

Approximately US\$1 million have been utilized for handpump research and trials in the rural water programmes over the past four years. The yearly total investment on wells with handpumps is approximately US\$2 million. An increase is foreseen for the coming year.

The Maintenance of Handpumps

Handpumps do not require high investment costs and are relatively simple and cheap to maintain when compared to engine- or motor-driven pumps. The objective behind testing and development of handpumps is to determine which types are durable and easy to maintain and manufacture locally. When breakdowns occur, spares are to be available. Preventive maintenance, however, is required even for a handpump of high quality. The goal is to get villagers ("close to the users") to be in charge of the maintenance. This goal has not yet materialized, one reason being the unavailability of the types of pumps suitable for village maintenance and spare parts. Although it has not been given enough attention, the possibility of introducing caretaker training programmes has also been considered. The prevailing system is one in

which the central water authority is in charge of the maintenance. Preventive maintenance hardly exists, and curative maintenance is often late. Again, this is due to the unavailability of mechanics, transportation facilities and spare parts. A programme under preparation in Rajasthan in India, however, provides one example of how preventive as well as curative maintenance at the village level--the so-called one-tier system--can work. Under this system, a trained caretaker is responsible for the maintenance of 30-40 pumps. After a training period of three months, the caretaker is contracted by the community. He is supported with a starting loan for tools and a bicycle. A small store of spares as well as funds is provided by the villagers.

The costs for maintenance are very low compared to the investment costs. A handpump may cost US\$100 to \$300. The cost for a borehole equipped with, for example, an India Mark II pump, platform and drain is US\$1,500 to \$2,500. The cost of the pump is thus roughly 10 percent of the total cost. If we return to the Rajasthan case, the yearly maintenance costs US\$30 to \$40, i.e. about 20 percent of the cost of the handpump or about 2 percent of the total investment. Thus, to neglect the maintenance--resulting in an unoperational pump--seems unwise. Yet poor maintenance is the primary cause of why sometimes 50 percent of the handpumps or more do not provide water.

Until now, testing and development have been concentrated on the physical performance of the handpumps. Much more attention must now be given to the integrated development of pump maintenance systems and training of maintenance personnel at the village level. It is, however, evident that there is not any standard solution at hand for operation and maintenance. The systems have to be adapted to the socioeconomic conditions where applied. In general, however, much more attention has to be paid to the operation and maintenance problems than is presently being done.

Handpump Developments in Sweden

The market for handpumps in Sweden is very limited. Nowadays, handpumps are used only at remote private houses. Such pumps are used only for obtaining a certain number of buckets of water a day for perhaps three months a year. These pumps therefore do not meet the requirements of a pump for village water supply. There is, however, considerable interest among researchers and manufacturers in Sweden to develop a durable pump that can meet the requirements of the water development programmes. There are several pumps that have already reached the stage for field testing.

Bearing in mind the amount of ongoing research into handpumps and the fact that most industrial countries are busy developing pumps for use in the developing countries, as well as developing their own pumps, a new generation of handpumps may soon be born.

With this in mind, a handpump testing project was begun at the University of Lund in Sweden in 1982. The project has two main objectives:

- technical development and evaluation of new designs; and
- comparative tests of handpump components, especially the cylinder assembly (see also Appendix).

APPENDIX. HANDPUMP TESTING AND DEVELOPMENT

The Project described below was started early in 1982 at the Department of Environmental Engineering (EE), University of Lund, Sweden. It is a continuation and extension of a test work done earlier by Mr. Oscar Carlsson at the Mission Covenant Church of Sweden (MCCS). The project is financed by MCCS and run by Mr. Robert Hahn (EE) and Mr. Oscar Carlsson. MCCS, together with Hindustani Covenant Church in India, started Sholapur Well Service (SWS) in 1968. SWS is involved in the drilling of deep wells and handpump manufacturing. The well-known India Mark II handpump is basically designed from the original SWS pump which was developed in 1971. At present, Mr. Carlsson is working at SWS in India.

The objective of this project is to improve handpumps for rural water supply. The programme involves two major components as described below:

1. Technical development and evaluation of new designs; and
2. Comparative tests of handpump components, especially the cylinder assembly.

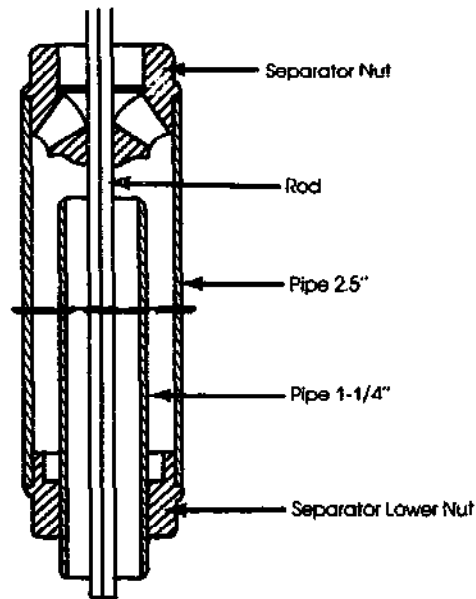
Development

Most of the design work presented here refers to models designed by Mr. Carlsson. The three products described here have been tested in the field and/or the laboratory. The intention is to begin production as soon as sufficient field experience from the prototypes is available. The designs will not be protected by patent.

The particle separator has been designed because particles (trapped during installation from wear in the pump and the pipe or from suspended matter in the water) will substantially increase the wear on the cup seals. A prolonged life for the cup seals will effect not only on the pump reliability, but also the resources required for maintenance.

To avoid accumulation of settling particles on the cup seals, the separator is placed right above the cylinder. At the upward movement of the piston, it serves only as an extension of the rising main. Through the design of the top nut, settling particles are directed to a side pocket around the pipe. The length of the device has been chosen to give a particle storage volume large enough for whatever operation time is required. When the cylinder is removed for maintenance, the separator is emptied.

Principle of the Particle Separator



The plastic foot valve is designed as extrusion moulding, which will provide for a comparatively low production cost. Basically, it consists only of two parts, thereby simplifying both the installation and the handling of spare parts. The moving part is cone-shaped, which provides for a very low head loss and a smooth opening and closing of the valve. To ensure complete tightening, a rubber o-ring is inserted in the cone. Field and laboratory tests will determine if PVC can give sufficient stability to the construction, or if the more expensive POM-plastic will be needed. At present, this foot valve is made of gun metal, with the moving part made of PVC.

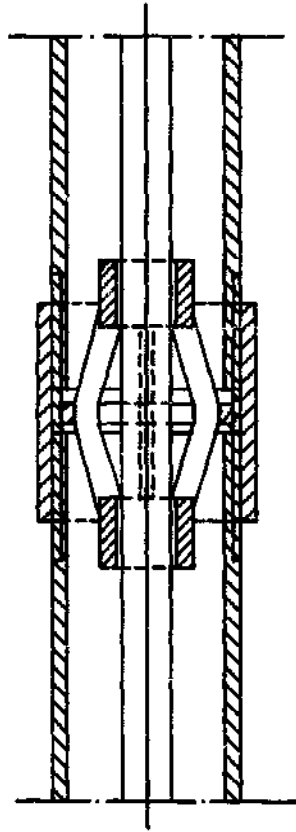
The rod guide is designed to overcome problems related to the "snaking" of the pump rod in the rising main. If the rod constantly touches or hits the main pipe, the wear will sooner or later result in damages to the pipe or the rod couplings. After 3 - 5 years, some pipes will start to leak.

The guide is to be installed in the couplings between the pipe parts. The steering of the guide is done in two points on the rod. The risk that the guide, if broken, will lock and hinder the operation of the pump is therefore very small.

The rod guide has been field tested in India for about one year. After this time, the guides performed as if new, and the rod couplings had not touched the rising pipe.

The guide is produced in gun-metal moulding. Little machining is required afterwards, which means that the costs can be kept low.

Design of the Pump Rod Guide



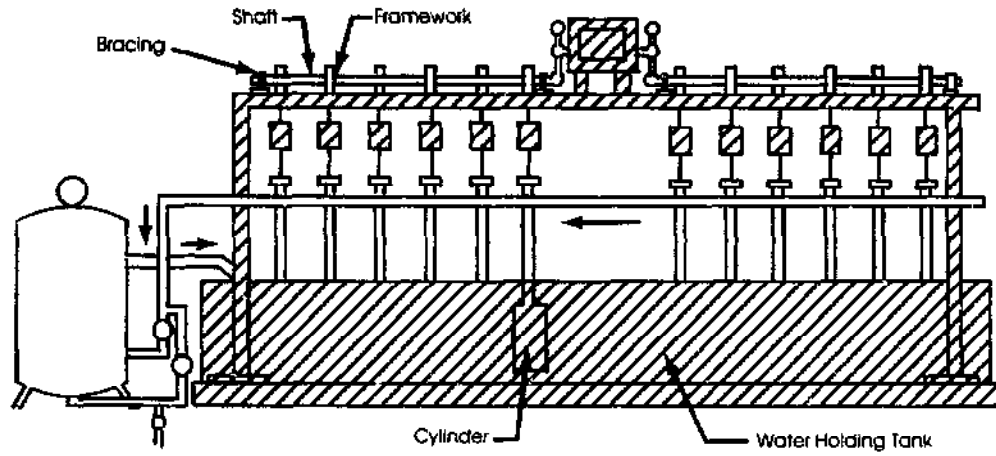
Laboratory Tests

For endurance tests, a test rig which has a capacity of operating 12 cylinders at a time is used. It is electrically driven, and the pumps make 50 strokes per minute. With recirculation of the water over a pressure tank, an operating head of 30 m (adjustable) is maintained for the pumps. A record is kept for each pump, as to total number of strokes, volume pumped, and capacity and condition of the components.

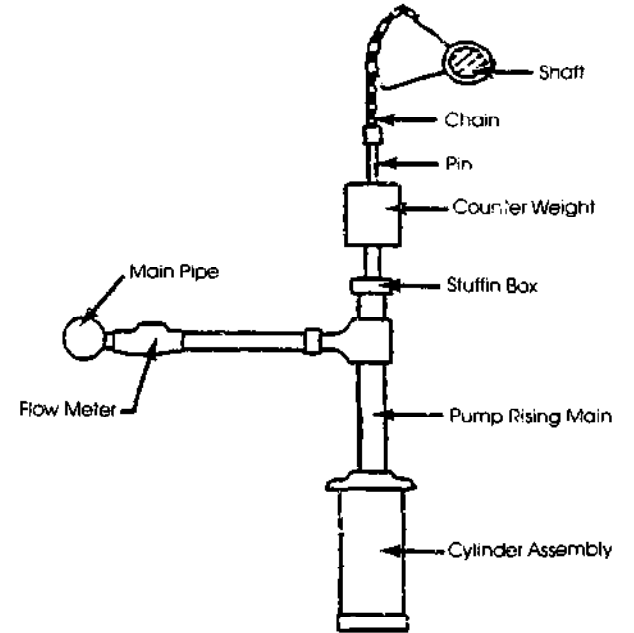
Data are collected on the performance of the following:

- the connection handle--pumprod;
- the plunger;
- the cup seal;
- the foot valve;
- the cylinder.

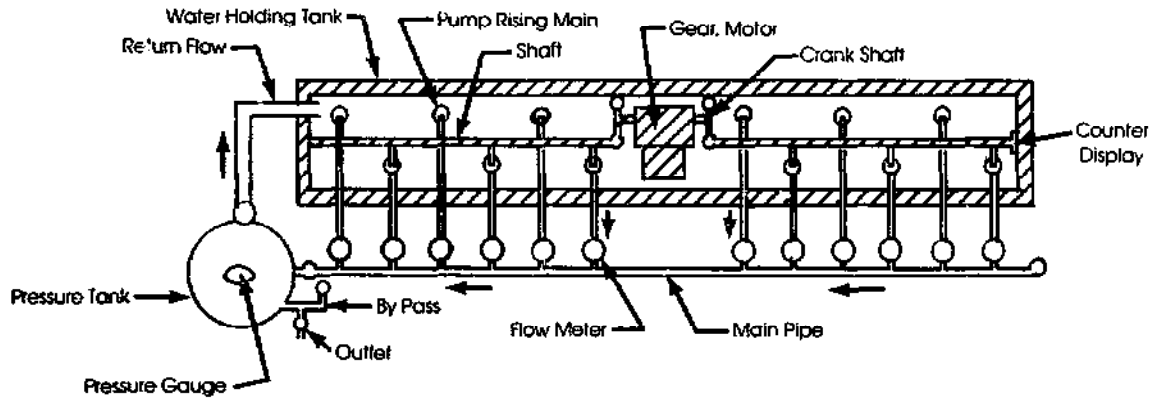
SIDE ELEVATION



SECTION DETAIL



PLAN



The operation of the rig began in June 1982. Some unexpected problems occurred at the beginning, and modifications had to be made. By the end of 1983, the rig had operated for about 27 million pumpstrokes--a little more than one year of continuous operation. Results from the test rig are therefore achieved 4-6 times faster than from field tests, i.e., 2 months in the laboratory correspond to up to one year of operation in a village.

Alternatives to the SWS India Mark II-type chain connection between handle and pump rod are being tried. The most promising result is from a synthetic band, installed in a double layer in such a way that the load on it is alternating between the inner and outer band. This type of connection will be further tested in field installations.

The main interest has been directed to the cup seals. Different leather qualities, as well as synthetic materials, have been tested. The best results with leather thus far have come from a Swedish-manufactured impregnated leather. Even better performance comes from a nitrile rubber seal, which unfortunately is relatively expensive. Still, it can be wise to pay the higher price in order to reduce maintenance costs in terms of a lowered number of seals to exchange per year in a certain area. This seal is to be tested in the field.

Type	Place of Manufacture	Millions of Strokes	Result
LEATHER			
Vegetable Tannage	India	15.0	Upper seal worn out
	Sweden	(21.6)	Lower seal heavily worn
Chrome Tannage	India	9.3	Lower seal worn out
	Sweden	(14.9)	Both seals worn
Impregnated	India	(18.3)	Upper seals heavily worn
	Sweden	(20.2)	Both seals in good condition
SYNTHETICS			
Teflon/Graphite	Sweden	3.7	Heavily worn
Nitrile rubber	Sweden	(25.4)	Worn but in operating condition

Comparison of some results from the cup seals being tested. Figures in brackets indicate that the seal is still operating.

The SWS plunger performs very well with a plastic cone instead of a rubber ball. The leakage is low and the head loss is lower than other plungers. Most important is the reliability, believed to be high.

Different foot valves are being tested. Several modifications of the same concept built on the plastic cone for opening and closing have been tested. Iron valves are not to be recommended. POM or PVC plastic nuts and valve seats can be used if properly designed. If produced by extrusion moulding, the price will be very modest. Gun metal valves may also be a good alternative.

In addition to this basic endurance test, other measurements, e.g., pumping efficiency and pressure flux, have given us an increased understanding of how the reciprocating pump operates. We believe this experience will be of value for future tests and development work. Other designs or materials and devices from other pump manufacturers can be evaluated and compared directly to the ones already tested under exactly the same testing conditions.

For a full test report, write to
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HANDPUMP EXPERIENCES IN PROJECTS FINANCED
BY THE DIRECTORATE FOR SWISS DEVELOPMENT COOPERATION AND
HUMANITARIAN AID (SDC), FEDERAL DEPARTMENT OF FOREIGN AFFAIRS

Armon Hartmann
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SDC POLICIES RELATED TO THE IDWSSD

The general policy goals of the SDC are directed towards assistance for underprivileged groups in Third World countries. In regard to those activities related to the IDWSSD, the main efforts are directed towards the provision of clean water (and sanitation) for rural populations of developing countries. At present, SDC is participating in 50 projects in 24 countries dealing with water supply and/or sanitation or rural/urban integration with water/sanitation components.

PRIORITIES

Priority is usually given to those types of water supply which need little maintenance and with which costs for importing spare parts and fuel can be kept as low as possible. Particular types considered are as follows:

- Water points (spring catchments with small storage tanks at spring sites);
- Shallow wells;
- Gravity water supply (with or without distribution systems);
- Boreholes with handpumps;
- Boreholes with diesel or electric motor/pump, pump main storage and distribution;
- Windmills, solar pumps.

CHOICE OF HANDPUMPS

If installation of handpumps is given priority, the type already in the particular country or area is usually selected for the SDC-financed project. It is our aim to keep the number of different types of handpumps to a minimum in order to ensure both a better supply of spare parts and a well-functioning

maintenance system. The basic condition, however, is that the pump already installed meets the necessary conditions of ease of operation and maintenance and acceptance by the users.

- In the village water supply project in Lesotho (Southern Africa), carried out with the Ministry of Cooperatives and Rural Development, the project opted for the Mono Handpump made in the Republic of South Africa. All the boreholes then pumping with a diesel or electric motor pump were equipped with Mono pumps. The maintenance teams were already familiar with this type of pump, and the rural population accepted it. A handpump of similar type (and interchangeable for all parts at the below-ground level) was already included in the programme of a major donor country. Several other pump types (e.g., Consallen, India Mark II) were also installed under the handpump test programme in cooperation with CATR in London.
- In the Cabo Delgado (Mozambique) Water Supply Project, Blair pumps were installed for pumping from the shallow wells along the coast. Although ideal in that a neighboring country supplies the handpumps and spare parts, the project suffers greatly from very frequent pump breakdowns. At present, different pump types are being installed to determine their suitability for the local conditions and their acceptance by the users.
- Very detailed information is available from the borehole and handpump project in Southern Mali, which is based on the detailed study "Moyens d'exhaure--inventaire, observations et recommandations au sujet des pompes a motricite humaine" prepared by a consultant for Helvetas, the Swiss Association for Technical Assistance, who carried out this project on behalf of the SDC.

Despite the low delivery rate (only about 50 percent compared to other pump types installed at the same depth), the Vergnet pump is performing well in Mali. With some minor improvements and modifications, this pump could be a successful VLOM pump candidate. Still, the major problems are the relatively high cost and the need to import the pumps from a European country. The purchase of the necessary replacement plastic pipes is an ever-increasing strain on the foreign exchange budget of the country. The India Mark II pumps installed are also performing well. Replacing the borehole steel pipes with PVC pipes and implementing the new cylinder design which allows the pump rod and piston to be withdrawn easily for repairs will greatly facilitate installation and maintenance. Three Consallen pumps and six Bourga pumps have also been included in the handpump test programme.

DEVELOPMENT OF HANDPUMPS

The SDC is also participating on the development of handpumps in two countries:

(a) EMAMA--Mali

Based on an evaluation mission by the UNDP in October 1981, the SDC is co-financing the development of local pumps produced by the "Enterprise

Malienne de Maintenance (EMAMA)" in Sikasso. The pump design is based on the India Mark II, but has been adapted to suit local conditions, local materials and available technical workmanship. The project, which is carried out by ONUDI, started production in late 1982 and, according to the latest reports, the first 100 EMAMA handpumps have been manufactured and are being installed in the UNICEF project in Mali. Although the production rate will probably reach 1,200 pumps per year, it would be advisable to keep production during the first phase relatively low in order to gain experience in installation and maintenance. This would allow the project to test the pump and make the necessary adjustments and adaptations for the improvement of the EMAMA pump before large-scale production is begun.

(b) The Sihilase Handpump in Sri Lanka

The history of this handpump goes back to 1978, when the first model--consisting of a timber piston, PVC-cylinder and rise pipe, and angle-iron/pipe frame and handle--was manufactured. During the subsequent years, the Sihilase pump was improved through collaboration between the project and SKAT (the Swiss Centre for Applied Technology) in St. Gallen. All parts of the pump are manufactured locally in Sri Lanka, and the total costs for the pump and six metres of casing amount to about \$130 per pump. The handpump has recently been tested at the CATR laboratories (as part of Batch 4) and, despite repeated breakages of the PVC pipe pumprod and the handle (mainly due to bad manufacturing), it was felt that the Sihilase pump is worthy of further development because of the number of interesting design ideas. The Sihilase handpump is considered to be a potential candidate for the village-level operation and maintenance (VLOI) concept.

BRITISH AID INVOLVEMENT IN THE DEVELOPMENT OF
GROUNDWATER FOR RURAL WATER SUPPLIES

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INTRODUCTION

The existence of a readily accessible water supply has always been a very important element in the location of human settlements. The British Aid Programme has been concerned with water development projects for very many years and from the early 1970s has paid particular attention to the development of rural water supply systems. From that time, a large number of the international aid donors began giving special emphasis to rural development projects, in Africa in particular, where few countries had a water supply service coverage for their rural populations that exceeded 30 percent. In many instances a considerably lower level of service was provided. It was very clear that if extensive development of rural water supplies was to take place, then there was a need to look more closely at what was an appropriate standard of design for the equipment which would be employed. The advantages of groundwater extracted from both shallow and deep wells were readily apparent in view of the possibility of using water from these sources without additional treatment. Two areas, however, were worthy of special detailed review. These were the development of the wells themselves and the more efficient use of pumps.

HANDPUMPS

Where there is a suitable supply of groundwater, the use of handpumps is generally the cheapest means of providing a potable water supply. Handpumps have been available for many years; indeed in the western world, they were common a hundred years ago both for supplies to individual houses and for use in smaller village communities. In modern times the availability of piped supplies has relegated the handpump, as a source of drinking water, to a comparatively unimportant position. There has, however, been an increase in interest in the use of handpumps to provide safe drinking water in developing countries. This use has produced a number of problems as well as solutions. Many of these problems stem from the different social and cultural attitudes towards pumps in the developing countries, or from the lack of an adequate maintenance structure which can look after them once they are installed. It was, however, recognised that one of the major problems was the unreliability of the pumps themselves. This unreliability resulted from a number of factors:

- (a) The intensive use of a pump in a village water supply scheme, which may require it to be in operation for perhaps 12 hours of the day, when it was designed for only occasional use;

- b) The use of cheap and unreliable pumps in an effort to supply water to the greatest number of people within the scope of a limited budget;
- c) The choice of a poor pump, simply due to the lack of suitable, unbiased and reliable test data on the pumps available;
- d) Lack of sufficient knowledge of pumps to foresee those particular features which could clash with the cultural behaviour of the pump users.

There was a considerable number of handpumps available on the market, but nowhere were really satisfactory performances being achieved. In many ODA-funded projects, the reliability of the pumps themselves was a matter for serious concern and often figures as high as 30 to 40 percent were being reported regarding the number of pumps out of action at any one time due to mechanical failure. Since considerable investment was being made in the drilling and lining of wells, it was of paramount importance that handpumps withstood the rigours of day-to-day usage by large numbers of the people, not only from an economic point of view, but also to maintain the confidence of the people when persuading them to use pumps rather than to return to their traditional contaminated water sources. We needed to know which were the most satisfactory pumps in relation to performance and which provided the best value for money. We needed to know which was the best buy.

In the United Kingdom, the Consumers' Association was well-known for its comparative testing of products, providing consumers with value-for-money information; they were therefore asked to help. The Consumers' Association was given a contract to undertake the testing of 12 handpumps.

No standard test method or procedures for handpump evaluation had been developed, and discussions were therefore held with other aid agencies, such as UNICEF, in an attempt to discover how information on pump performance was obtained. Some laboratories had instrumented pumpheads to obtain information on the effort needed to operate the pump, but no one had ever looked at the complete pumping system as an entity. To do this, it was decided to place the handpumps on top of a tower and bring the cylinders up to ground level in a tank in order to examine their function more easily. The height selected for the tower was 7 metres, the nominal depth from which water could be lifted by a shallow-well suction pump. This was satisfactory for this type of pump, but since deep-well pumps were also to be considered, a means of simulating water depths up to 50 metres had to be devised--a difficulty compounded by the fact that the reciprocating pump rod had to be accommodated. Subsequently, a head-simulating valve was developed, built and calibrated, and this provided a means of assessing on a comparative basis the efficiency of a handpump at various water depths and pumping speeds. By use of strain-gauging techniques, forces developed throughout the entire pumping system were examined and losses were pinpointed as closely as possible.

Performance and pumping efficiency could now be ascertained, and engineering assessments of the manufacturing quality, design, sanitary protection and safety of operation could be noted. In many projects, the Consumers' Association had made great use of user panels to obtain subjective assessments of performance to compare with laboratory results. It was

considered even more important with handpumps, since it was generally the women and children who had to obtain the water; therefore, a controlled user test was carried out.

The last aspect to be considered was the endurance of the pumps over long periods. It was decided to use four 1,000-hour periods with increasing severity of water conditions and a pumping speed fast enough to keep the pump under pressure of heavy use, but not so fast as to induce breakdowns unfairly. The pumps were therefore to be operated at 40 strokes per minute for 24 hours a day with careful examination at the end of each 1000-hour period. Once the test method had been developed and assessed, it was discussed and agreed with ODA, and the work of testing began.

The objective of the exercise was to provide ODA with a great deal of information on the behaviour of handpumps to enable the most appropriate selection to be made when pumps were being considered for aid-funded projects. It was also desirable that the results of the tests should be made available to manufacturers, so that they be given the opportunity of looking at any weak points discovered in their products during the testing procedure, thereby helping them to improve their products and provide longer-lasting handpumps for consumers in developing countries. The report on the testing of the first 12 pumps was released in October 1980, and attracted considerable interest from aid agencies and from pump manufacturers internationally. As a result, UNDP and the World Bank became interested in the project and agreed to fund the testing by Consumers' Association of a much larger number and greater selection of pumps from a number of countries. This further, much more extensive, programme of testing has now been completed by the Consumers' Association, and the reports have been published.

As a result of all the testing carried out, it was readily apparent that an ideal pump did not exist. All had problems and faults to a greater or lesser degree. UNDP/World Bank then came up with the idea of trying to develop the ideal pump, and ODA joined with them in investigating a number of elements needed to meet this objective. The ideal pump needed to be cheap, robust, and capable of manufacture in a developing country. It also required those forms of maintenance and service which could be readily provided by people of only moderate mechanical skills in villages where the pumps would be installed.

As a result of other work being carried out in the development of low-cost groundwater installations in Malawi, ODA became interested in three elements in particular in connection with appropriate handpumps. We wished to develop a suitable pumphead which was robust, capable of local manufacture, and, through the down-hole components, could be withdrawn without removing the pumphead itself. This led to the development of the Maldev Pump, in cooperation with the government and private resources in Malawi. Training courses were also begun for village pump caretakers. Improvements were made in the installation of handpumps and upgrading of pump platforms, leading to considerable improvements in rural community water supply schemes. Roller bearings within the pumphead, however, soon produced a number of problems, and the Consumers' Association was therefore engaged once again in attempting to develop acetal bearings as a substitute for the rollers. This is the second element of the programme with which we have become involved, and improved bearings are now being tested extensively.

Basic problems still existed, however, with the maintenance of the below-ground components of the pumps, which generally used galvanised mild steel rising mains, rods and heavy metal cylinders and foot valves. These required mobile maintenance teams for their repair and servicing, and it was recognised that this was a real problem in terms of both cost and the continuation of the operation of wells in rural areas. The obvious answer was to move away from heavy metal installations to lighter systems using plastics. Unfortunately, the facilities for carrying out this research and development work in Malawi were extremely limited. Some work had been done in Kenya and in India, but it was generally thought that more sophisticated facilities would be needed in the development stage; therefore, the Consumers' Association was again approached for assistance. ODA and the World Bank agreed to jointly fund this project and the terms of reference required that the pump parts were, if possible, to be made of plastic materials available in developing countries and in a form as simple as possible in order to enable volume production. This would ensure continuing supplies of cheap, accurately produced spares. The design of the cylinder should not require anything other than the simplest of tools to dismantle it, and the unit should be capable of working down to about 45 metres with an extractable foot valve, and, if possible, should produce about half a litre of water per stroke. Work on this project has now been underway for some time, and after laboratory tests, some units are now undergoing field trials in Africa.

WELLS

It was recognised that, in addition to the problems of the pumps themselves, much more attention needed to be given to the boreholes. Experience had shown that, in many cases, handpump failure had frequently been caused by sand pumping, due to poor design of gravel packs or incorrect well-screen slot size. Major cost savings could be expected from improving borehole design in respect to these issues.

A general project in Malawi was therefore put together by ODA and the Department of Lands, Valuation and Water. ODA's principal agent in the execution of this project was the British Geological Survey. The scheme was designed to last three years, between 1980 and 1982, during which time the concept of an integrated programme was initiated and developed as a substitute for the then-current dispersed programme of borehole construction. Design criteria aimed at providing a basic supply of 27 litres per head per day within a walking distance of less than 500 metres for the majority of the population were agreed upon. The integrated programme comprised the following:

- (a) Rehabilitation of existing boreholes where feasible;
- (b) Construction of low-cost boreholes of improved design;
- (c) Protection of suitable existing dug wells;
- (d) Construction of protected dug wells;
- (e) Establishment of a maintenance structure for all water points.

The new design of boreholes is cheaper and more efficient than the old, and the overall construction costs have been lowered by a concentration of effort in localised areas, also allowing for selection of the most appropriate of the various water supply-type options. Cost comparisons of the integrated versus the original dispersed programme are shown in Table 1 below.

TABLE 1

SUMMARY OF COSTS IN RURAL WATER SUPPLY PROJECTS IN MALAWI
(common schedule of prices, 1983 rates)

<u>Dispersed Country Programme</u>	<u>MK</u>
60-m well with steel lining and Climax Handpump	8000
45-m well with steel lining and National handpump	6000
<u>Integrated Projects (average costs*)</u>	
(a) Livulezi 134 drilled wells with average depth of 24 m and Malawi handpump	2400
(b) Dowa West 67 drilled wells with average depth of 27 m and Malawi handpump	3100
(c) Dug wells in both projects with average depths of 6 m and Mk V handpump	750

Cost Breakdown of Integrated Projects--Drilled Wells

Direct labour and material costs	33%
Project transport	33%
Project overheads (supervision, depreciation, camp costs, etc.)	33%

Water abstraction is by handpump and has long been a standard feature of groundwater development in Malawi, mainly because of the low permeability of the typical basement aquifer which underlies the greater part of the country. A major constraint, however, to operational efficiency has been the

* Costings take account of unsuccessful wells. In Dowa West, cost increase relative to the Livulezi project relates in part to lower success rate consequent on water quality or insufficient yield.

1 Malawi Kwacha = 1 US\$ approximately

high pump failure rate which can sometimes reach 50 percent for any given time. Observations had shown that a major cause of this failure lay in borehole design and was chiefly associated with the effects of sand pumping. As an indication of this situation, the standard replacement rate of cup leathers at six monthly intervals should be noted. In the 24 boreholes constructed for the Livulezi feasibility project and fitted with standard handpumps, no replacement of cup leathers has been required in one and a half to two years of subsequent operation.

Further research into improved well construction techniques is now underway both in the UK and overseas. In particular, we are looking at the possibilities and methods of horizontal drilling to increase the infiltration rate of wells, as well as methods of borehole drilling by hand. In both of these areas, we believe China has considerable experience and knowledge which could be applied in other countries with substantial benefit.

SECTION 5

SUPPORT ACTIVITIES OF INTERNATIONAL ASSISTANCE AGENCIES

HANDPUMP TESTING BY THE CONSUMERS' ASSOCIATION
TESTING AND RESEARCH LABORATORIES, U.K.

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BACKGROUND

"Value for Money"

In the period following the Second World War, the variety of consumer goods greatly increased in England as well as many other parts of the world. Many new products, such as washing machines, television sets, and synthetic textiles and detergents, flooded onto the market.

Ordinary people who did not understand these products felt at the mercy of manufacturers and advertisers. Consumers had no professional institution or trade association from which to seek advice.

Comparative testing

Back in 1927 in the U.S., a book written by two economists called Your Money's Worth was published. It was a study carried out on the way government money was spent--and sometimes wasted. It revealed that whenever the U.S. Government bought products, the competing brands were tested to ensure that their purchases were reliable and a good value for the government's money. The U.S. Government, however, did not publish the results of what they had learned. The U.S. public lacked the opportunity to get better value for their money.

This was unacceptable to many people who saw the sense of comparative testing; therefore, some years later the American Consumers' Union was formed to carry out comparative testing of products for the benefit of consumers.

This led to the formation of a similar organisation in 1956 in the U.K. called the Consumers' Association. In October 1957, they published results of their first comparative tests in a magazine called Which?

From small beginnings, the Consumers' Association has grown in strength, supporting people with objective facts to compare with manufacturers' and importers' claims for their products. It has been instrumental in persuading governments of the need for legal safeguards of consumer rights to fight unfair and restrictive practices. It has remained completely independent. It has achieved its reputation by establishing in its laboratories, test procedures and methods which are soundly based, practicable, comparative and professionally executed.

COMPARATIVE EVALUATION OF HANDPUMPS

Development of a test method

In 1977, the Overseas Development Administration (ODA) discovered through various post-evaluation studies that handpumps being supplied by British Aid money to its developing country projects were often unreliable. They approached the Testing and Research Laboratories of Consumers' Association (CATR) and discussed possibilities of carrying out a comparative test on handpumps. One of the most stimulating aspects of the work at these laboratories is the necessity of handling the very wide range of products which come in for testing--many of which have no standard test methods. Ways and means have to be devised to accurately measure performance and durability of products ranging from toothbrushes to car tires. Handpumps were no exception. Some references to testing parts of handpumps were discovered but no standard test methods were available and it appeared that no one had looked at both the above- and below-ground parts as an integrated system. A test method was developed using a pump tower built especially for the tests; with relatively few modifications, the method is still used today.

Conference on Handpump Evaluation

Since no systematic attempt had been made before to examine handpumps, the ODA believed that the results of the tests should be sent back to the manufacturers. It was hoped that this would stimulate them into looking at ways and means of improving their pumps. The general interest that this work aroused persuaded the International Reference Centre for Community Water Supply in The Hague and CATR to organise a conference on Handpump Evaluation in 1979--particularly relevant at this time since preparations for the International Drinking Water Supply and Sanitation Decade were already underway. This in turn proved to be of particular interest to organisations like UNICEF and the World Bank who were keen to see this work continued. The pump testing tower was originally built alongside the Harpenden Laboratory of CATR, but due to local council regulations, the tower had to be taken down by the end of 1980. This only allowed enough time to carry out detailed tests on 12 pumps for ODA, so the World Bank, with UNDP funding, agreed to have a handpump testing tower erected at the Gosfield Laboratory of CATR in order to continue with this evaluation work. Thus far, some 36 handpumps have been evaluated, and the results published by the World Bank in their Technical Paper series.

Test Method Refinement

Just as pump development was stimulated among manufacturers, the test method itself began to be refined because of the need to obtain information more quickly and efficiently to keep testing costs down. Essentially, however, the methods of evaluation have remained the same to allow for continuous comparison of efficiencies of handpumps tested over the years. Among these changes, the most significant are greater use of video recordings to study ergonomic problems of users, and the amalgamation of the endurance test into two periods instead of four.

UNDP/WORLD BANK HANDPUMPS PROJECT

Global Field Trials

One of the stated objectives of the International Decade was to set up global field trials in some 20 countries in order to compare the efficiencies of various handpumps, identified as being satisfactory in the laboratory tests, under differing field conditions. It was also hoped that these trials would demonstrate the value of using reliable handpumps in rural water supply projects and stimulate developing country governments and other aid agencies to extend this activity.

Having identified some suitable handpumps, the World Bank, together with other agencies, launched their Global Field Trial programme. One of the problems, however, in identifying the economic benefits of an improved rural water supply scheme was the lack of means of measuring the actual output of water. In other field trials, attempts to obtain this information by observation had been unsuccessful and, because of the widely differing handpump outlets, water metering was considered impossible.

Water Flow Monitor Development

About this time in CATR Laboratories, work was underway to develop a device to measure the precise amount of operating time of an electrical appliance. It was discovered that with a modified electronic measuring system, the device could monitor the length of time water flowed out of a handpump spout. The system could be adapted to fit any type of pump outlet and with a predetermined calibration figure, the approximate amount of water flowing out of the pump could be established. The accuracy was anticipated to be approximately 10 percent; this was quite sufficient as it takes into account the uncertainty of other parameters.

A pilot trial of 6 monitors was carried out in Lesotho, Southern Africa and they worked satisfactorily. Simultaneously, a further 12 were under test in CATR's laboratories at Gosfield, attached to handpumps installed in the tower. Results proved that this method of measurement was feasible and valuable since no better way had been discovered of assessing the amount of water which was delivered by a pump. It also had a second benefit of indicating the length of time a pump had been in use per day--an aspect of usage unable to be obtained by any other method.

Flow Monitor Production

The World Bank ordered 400 monitors to be manufactured, and those have now been sent out for pumps in field trials in West and East Africa, Tanzania, Sri Lanka, Bangladesh, India and Southeast Asia. There have been problems of battery life, water ingress and installation on the pumps, but it is hoped that with modifications these difficulties will be overcome.

MALAWI PUMPHEAD - THE MALDEV

The Development

The ODA was spending a great deal of time and money on a variety of groundwater projects in Malawi and had instigated work on a locally produced pumphead. This development was of great interest to the World Bank since it made the most of skills and manufacturing facilities available in a developing country. The pump was designed so that the cylinder could be removed without having to dismantle the pumphead and was consistent with the World Bank's Village-Level Operation and Maintenance (VLOM) concept.

Dry Bearings

Early samples of the Maldev pumphead revealed that there were manufacturing problems in the fitting of ball bearings in the handle and pumprod hanger. This led to discussions between ODA and CATR about the development of a dry bearing system which could be made from freely available engineering plastics capable of being moulded on existing developing country machinery. This would offer potentially cheaper components, thereby easing and simplifying the manufacturing processes, and allow the villagers to carry out their own maintenance without the need for costly intervention by government-financed maintenance teams.

The India Mark II handpump proved very successful in India, but it was uncertain whether its success would be repeated under African conditions. The Maldev head design, on the other hand, was potentially the most promising solution because of its simpler construction and ease of maintenance at the village level--and even this could be improved if a dry bearing system could be developed. ODA funded the initial development work and the most promising designs were endurance-tested under arduous conditions on laboratory rigs. Several sets of different bearing systems were sent out as a pilot field trial to Malawi to see if the initial ideas on the ease of maintenance and bearing life were justified. Preliminary information appeared to be hopeful, so the World Bank and ODA agreed to fund a further project looking at the possibilities of using other readily available materials and alternative bearing designs.

A twelve-month life for a bearing seems probable, providing sufficient care is taken to use properly finished pins with the correct bearing system. The suggested designs are presented in Annex 1.

Pump Cylinder

The Maldev pump still used heavy metal below-ground components, requiring the use of heavy lifting gear for any maintenance need. Numerous ideas for the use of lightweight plastic materials were suggested, but within Malawi, there were insufficient resources to undertake this work. CATR offered to assist, and because the World Bank was interested in the wider application of the use of plastics, they agreed to fund the project jointly with ODA, and terms of reference for the work were drawn up. Broadly, they specified the production of components using cheap, readily available plastics capable of

being moulded on existing developing country machinery. The cylinder assembly should produce around 0.5 litre per stroke and, if possible, should be able to work from a pumping head of 45 metres.

PLASTIC BELOW-GROUND COMPONENTS

Plunger and Foot-Valve Development

Some initial ideas for these components were provided by the World Bank's East Africa Regional Project Officer. Discussions were held with manufacturers of plastic materials, and numerous designs were produced. Prototypes based on the three most promising designs were machined from solid bar stock, and a fourth concept using a rolling diaphragm was developed with assistance from the Research and Development Division of Dunlop, a leading company in the rubber fabrication industry.

A special tank was built into which these prototype cylinders were placed, and suitable test gear was set up to drive them. Above each cylinder, a new type of pump rod connector was positioned so that some experience could be obtained on their behaviour at simulated loads equal to 25 metres and 45 metres water depth. A static load of over 1.5 tonnes has been applied to these connectors without causing breakage.

Pipe connectors

A uPVC pipe connector was also designed and developed; this connector can be fitted in seconds on the ends of lengths of uPVC pipe and can be removed easily with a small lever. Because it used standard stub flanges, the original prototype was too large to fit inside a 4-inch (100-mm) well casing. A smaller version has also been designed, however, to join pipes up to a 2.5-inch (63.5 mm) bore and to fit inside a 4-inch (100-mm) well casing. Full testing of these components has not yet been undertaken, but problems concerning the commercial implications of these developments are being examined.

Field Testing of Prototypes

While the endurance testing of the cylinders continued on the laboratory rigs, samples were made up and sent to Malawi and Kenya for testing. Apart from showing a failure in part of the footvalve-locking mechanism--which had occurred in the laboratory tests also--the units still appear to be working satisfactorily after 9 months. They are set at about 20 metres, and two men can remove the cylinder without any special lifting gear in less than 10 minutes.

As a result of the laboratory tests, various modifications at 45 metres were needed, and in October 1983, the final designs were submitted to ODA and the World Bank.

Moulded Components

A continuation project was agreed upon by the World Bank and ODA to manufacture a space model exactly as specified by the drawings to check that all the components fitted together and to provide the toolmakers with

essential information for mould tool design. Small modifications were suggested to make moulding easier, and various points of development suggested by the Regional Project Officers of the World Bank were undertaken. A full set of drawings has now been tested, the manufacture of the tools is underway and enough parts for 120 below-ground assemblies will be produced for further testing in the global field trials.

The general assemblies of these designs are shown in Annex 2.

LIGHTWEIGHT PUMPRODS

Direct-drive pumps, such as the Ethiopia BP50 or the Tara pump in Bangladesh, offer considerable advantages to the manufacturers, those persons responsible for pump maintenance, and possibly to the users. The Canadian PEK pump is smaller and has used the concepts of a low-mass, high-volume pumprod, which allows direct lifting of water from 50 metres.

The original project was to look at available materials and establish which would be the best, but before considering these, it is felt that certain basic theoretical information on the operation of the system needs to be determined. A terms of reference for this work is currently being prepared. This will be submitted to the ODA and the World Bank, who again will be collaborating to finance this work.

OTHER ACTIVITIES

Study Tour for Chinese Engineers

In September 1983, a Study Tour was organised for six engineers from the Ministry of Machine Building Industry, the Chinese Academy of Agricultural Mechanisation Sciences, and the Hunan Provincial Research Institute of Agricultural Machinery to discuss methods of handpump evaluation and development and to familiarize them with methods used in CATR Laboratories. It had been decided to establish two handpump testing facilities in China in order to assist Chinese handpump manufacturers in improving their designs. CATR is assisting with the ordering of equipment for the performance and endurance tests, and further technical assistance will be provided when the pump testing facilities are operational.

India Mark II Handle Bearings

There is growing concern that with some 500,000 India Mark II pumps in the field worldwide, the eventual replacement of the ball races will be a difficult task and may lead to a shortened life of the new bearing due to faulty installation. CATR has been asked to look at possible designs using engineering plastics which would allow the replacement of the handle bearing in the field to be carried out inexpensively by the villagers without the need for special tools. It is hoped that an opportunity will be provided to manufacture some of these bearing designs for both laboratory and field endurance testing.

CONCLUSION

As a Consumers' Association in U.K., we are pleased to have had the opportunity of putting our laboratory skills to use on projects which may be of material benefit to the lives of millions of consumers in developing countries. We hope to be able to continue in this work and, in some small way, help these consumers.

ACETAL BEARING DESIGNS

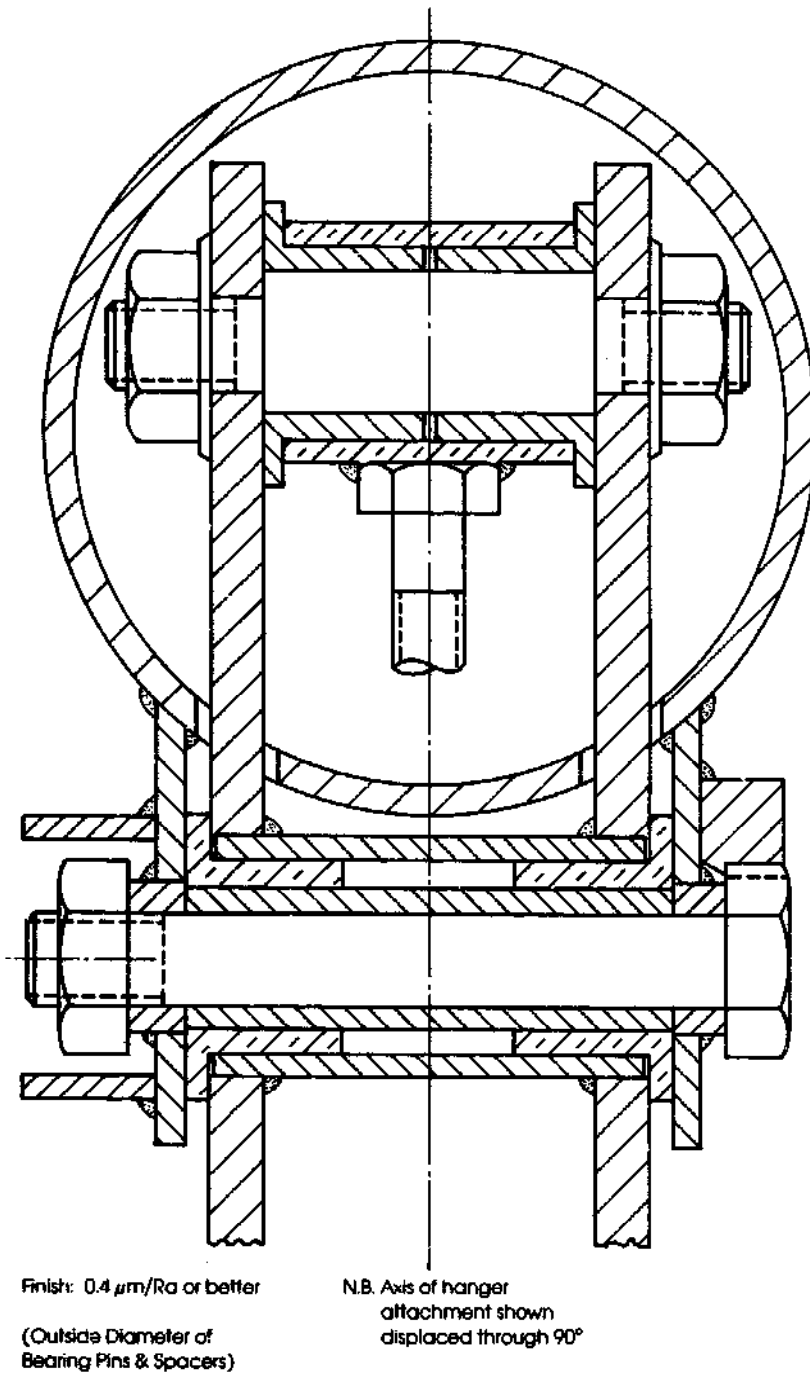
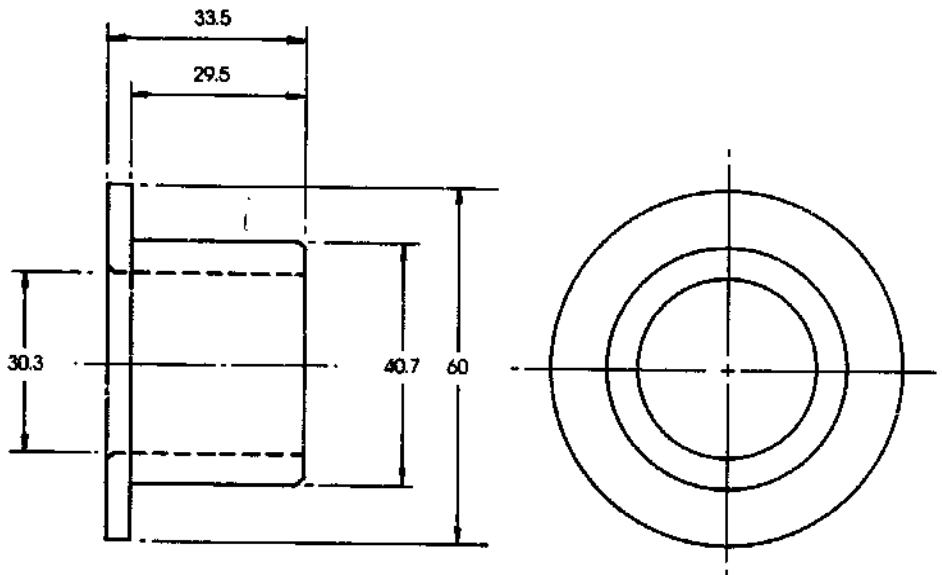


FIGURE 1 GENERAL ARRANGEMENT OF FULCRUM AND ROD HANGER ASSEMBLY FOR ACETAL BEARINGS MODIFIED MALDEV HANDPUMP--AFRIDEV

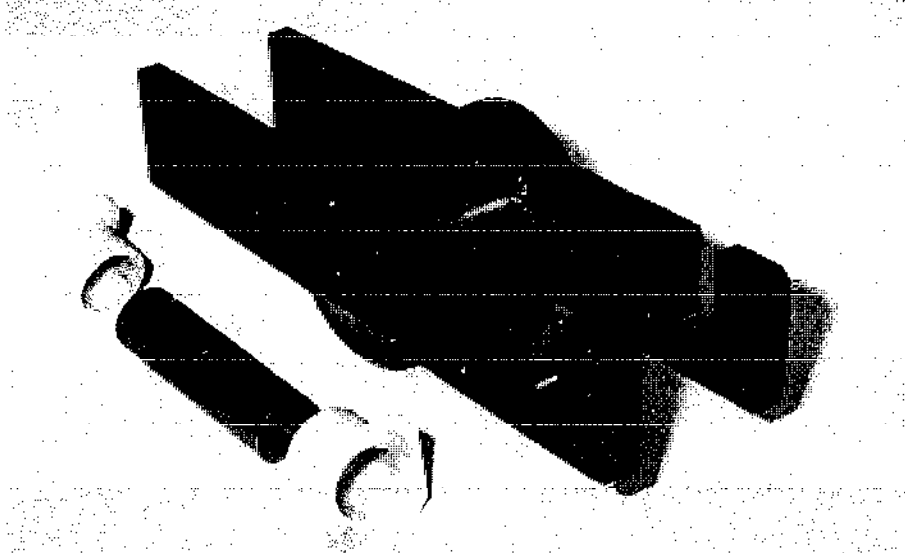


Finish: $1.6 \mu\text{m Ra}$ or better (Internal bore)
Material: Acetal Copolymer
No. Off: 4 Per Set
Dimensions of Test Bushes Shown
Dimensions of Production Bushes Depend on
Size of Available Stock Tube

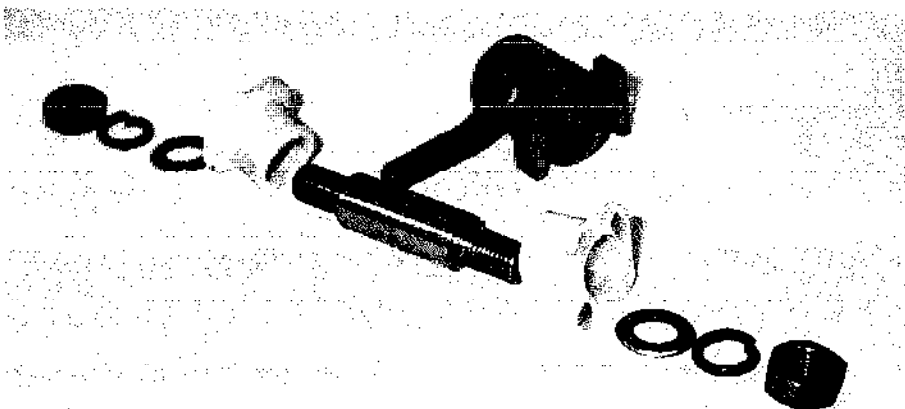
FIGURE 2 PLASTIC BUSH FOR HANGER AND FULCRUM BEARING



Three alternative
assembly designs



Fulcrum Assembly



Hanger Assembly

FIGURE 3 FULCRUM AND HANGER ASSEMBLIES FOR ACETAL BEARINGS

GENERAL ASSEMBLIES OF PLASTIC BELOW-GROUND COMPONENTS

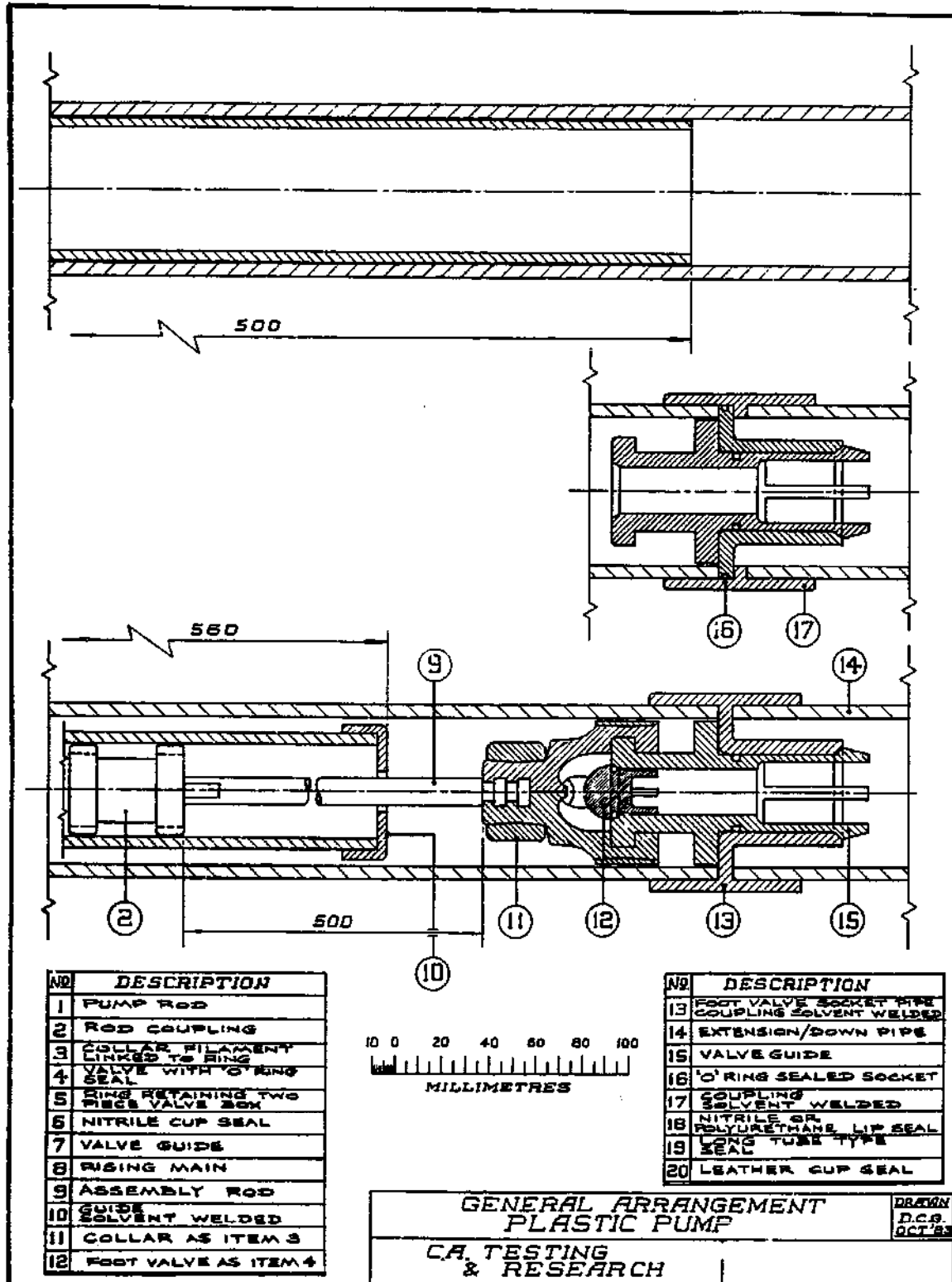


FIGURE 4 GENERAL ARRANGEMENT OF PLASTIC CYLINDER ASSEMBLY

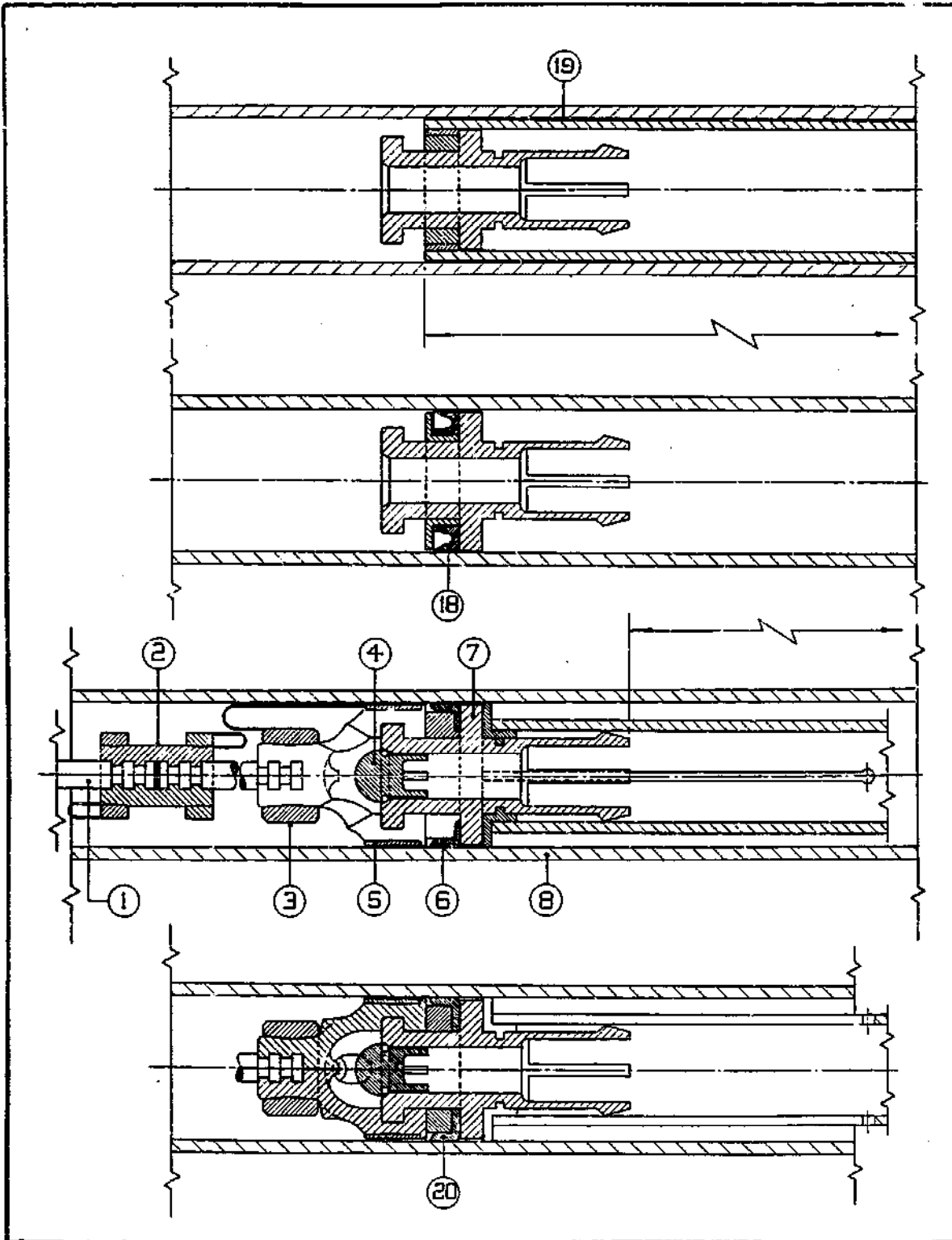


FIGURE 5 GENERAL ARRANGEMENT OF PLASTIC CYLINDER ASSEMBLY (continued)

THE IDRC HANDPUMP PROGRAM

Donald S. Sharp
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Water Supply and Sanitation
The International Development Research Centre

Water is essential for life. But water contaminated with disease-causing organisms can be just as deadly as no water at all. Three-quarters of the estimated three billion people living in developing countries do not have access to adequate potable water supplies or sanitation facilities. The worst affected are those living in rural areas. Even more disturbing is the fact that it is children under five years of age who suffer the most.

In response to the clear and urgent need for improved water supplies and sanitation facilities, the United Nations declared the 1980s as the International Drinking Water Supply and Sanitation Decade. The goal of the concentrated development decade is to provide adequate water supply and sanitation facilities for all by 1990. This enormous and ambitious task requires a vast commitment of resources. Providing clean water requires political will, technical expertise, and financial and material resources, all supported in a management structure capable of realizing plans as programs of action.

In areas where groundwater is readily available, the handpump is the simplest and least costly method of supplying safe drinking water. By the year 1990, some 1,833 million (1.8 billion) people in the Third World (excluding China) will require new, clean water supplies. Almost 1,400 million (1.4 billion) of those will be living in rural areas. To provide water supply services for many of these people, approximately 20 million or more handpumps may be needed by the year 2000. Replacement pumps will be needed for at least 500 million people during this same period, adding another 2.5 million pumps to the total requirement.

The International Development Research Centre is unique among international institutions in that it was established by the Parliament of Canada in 1970 as an autonomous public corporation to initiate, encourage, and support research into the problems of the developing regions of the world and into the means for applying and adapting scientific, technical, and other knowledge to the economic and social advancement of those regions. Strong emphasis is given to strengthening local research capabilities.

This is accomplished by providing support for Third World scientists and institutions to carry out research on subjects that are important in the context of their own countries' needs. IDRC staff provides guidance in identifying and developing research projects and assistance where necessary in the execution of the research.

The development of reliable handpumps that can be locally produced, installed and maintained at a reasonable price would be a major step toward providing reliable, safe drinking water supplies to those who need it most--the rural communities. Due to technical, social, and economic reasons, rural people in the developing world will be dependent on manual pumps for many years to come, not only for drinking water, but also for water for other domestic uses, livestock water supply, and small-scale irrigation.

The cost of a handpump varies from a low of about US\$20 (CA\$26) for a simple shallow-well pump, to a high of around \$2000 (CA\$2600), for a heavy-duty deep-well pump. The average cost per handpump is about US\$150 (CA\$195). The International Reference Centre for Community Water Supply and Sanitation put the minimum cost of bringing safe water and adequate sanitation to all by 1990 at an estimated US\$300 billion (CA\$390 billion)--even using low-cost technologies and community self-help. It is clear that governments and aid agencies alone will not be able to support the bill.

If any significant headway is to be made, it must be achieved through the efforts of the rural people themselves. This means that serious thought must be given to developing pumping devices that can withstand the use--and abuse--of large user groups. It calls for pumps that can be purchased, installed, and maintained locally. Even more importantly, it means that pumps must be manufactured in each country using available materials, thus reducing reliance upon imports. Governments must develop strategies to promote community acceptance and self-reliance at the village level. Programs for the effective transfer of the technology to the villagers themselves must be developed and implemented.

One of the most important problems in rural water supply programs is the high failure rate of conventional manual pumps. Failures occur mainly because pumps are not designed for the level of stress and abuse they routinely receive in the rural areas of developing countries. Because the materials from which conventional pumps are made--mainly cast iron and steel--are not only expensive, but also are not readily available locally, many developing countries must rely on imported pumps and parts, most of which are supplied by international and bilateral donors. This presents difficulties (for both donor and recipient) in terms of costs, maintenance requirements, and procurement of spare parts.

Since 1976, the International Development Research Centre (IDRC) has been supporting research in the development of more effective pumping systems for rural water supply. The approach taken has been to examine systematically the implications of new materials and improved pump designs. In view of the widespread introduction of plastics technology that has taken place in developing countries in the last decade, particular attention was focused on the polymer resins, specifically polyvinylchloride (PVC) and polyethylene (PE). Both materials are widely available throughout Africa, Asia and Latin America. In many respects, plastics technology is to developing countries what cast iron was to industrialized countries many years ago. The vast potential of plastics for use in handpump components has only recently been explored.

The IDRC-sponsored design work centered on developing a simple, low-cost PVC piston and foot-valve assembly for a manual, shallow-well pump. These

below-ground components--the piston and foot-valve--were designed to be interchangeable, thus saving labor costs in manufacture, simplifying maintenance procedures, and keeping the required number of parts to a minimum.

Early development research was carried out by a Canadian University, the University of Waterloo, and was completed in April 1978. The prototype pump assembly was then tested at the Consumers' Association Testing Facility in England as part of a project sponsored by Britain's Overseas Development Ministry. The tests established the reliability and efficiency of the Waterloo design as compared with the technology of the time. The Waterloo pump differed from others in the testing program in that it was designed specifically for manufacture in developing countries, utilizing existing, locally available resources.

The next stage, begun later in 1978, was to support research groups in several African and Asian countries to field test the pump. Trials were undertaken in Malaysia, the Philippines, Sri Lanka, and Thailand in Asia, and Ethiopia and Malawi in Africa. The primary objective of these research projects was to assess the Waterloo design in varying environmental conditions. The research was to determine the appropriateness of the pump for local manufacture and to estimate the cost of manufacture. Furthermore, the research was to evaluate reliability and durability, maintenance requirements at the village level, and technical performance of the pump. IDRC's approach was to provide the researchers with a prototype which the research team would reproduce and field test. As it turned out, the design was modified according to the availability of local materials and the results of further in-country laboratory tests. The above-ground components--spigots and pumpstands--were individually designed and locally produced. These modifications turned out to be an advantage, as it proved that a technology must first be adapted to local conditions before it can be successfully adopted.

In August 1980, a mid-project meeting for the four Asian projects was held at the University of Malaya, Kuala Lumpur, to review the projects' progress and establish common field monitoring and measuring techniques. A unique method for accurately determining pump usage by means of a mechanical counting device, designed at the University of Malaya, was incorporated into the field-testing program. This device made it possible to correlate measurements of wear with the distance the piston traveled, or the amount of time the pump was used, and made accurate field monitoring possible. This IDRC-sponsored field testing program is believed to be the first of its kind.

In the Philippines, the Institute for Small-Scale Industries, University of the Philippines, carried out the research in collaboration with the National Institute of Science and Technology, the Department of Local Government and Community Development, the Department of Health, and the Local Utilities and Water Works Agency. This project field tested 30 pumps in four rural communities. In Thailand, the Asian Institute of Technology conducted the research in collaboration with the Department of Health, the Department of Public Works, the Office of Accelerated Development, and the National Economic and Social Development Board. Fifty-four pumps were tested in three regions of Thailand. In Malaysia, the Faculty of Engineering at the University of Malaya conducted the research in collaboration with the Engineering division of the Ministry of Health. Pumps were field tested in two rural communities.

pressure-suction; one, pressure-lift; and five, lift-type pumps. In Sri Lanka, the Lanka Jatika Sarvodaya Shramadana Sangamaya (the Sarvodaya Movement), a non-governmental organization involved in grass roots community development work, carried out the research. This project field tested 21 pumps of three different above-ground configurations. In Ethiopia, it was the Department of Mechanical Engineering of the University of Addis Ababa that developed the pump models, some of which were installed by the Ethiopian Water Works Construction Authority (EWWCA). One of the six models was selected for extensive field trials. A total of 120 were manufactured, 84 installed in the field, and 10 monitored every two months over a full year. In Malawi, the Ministry of Community Development and Social Welfare was responsible for the project in cooperation with the Polytechnic Institute. A total of 60 pumps were monitored.

The research included an economic analysis of cost effectiveness when compared with other handpumps being used in the region. The researchers also assessed the potential for rural water supply development, made projections on percentage of rural households that could be served by piped water, and attempted to determine the future market demand for handpumps in the region.

Last year, in 1983, the research results of the projects in Asia were published (1). Of the four projects in Asia, the Sri Lankan and Malaysian projects were considered to be the most successful. The models designed in the projects are still functioning after more than three years of service. Based on their results, both projects submitted research protocols to IDRC for further studies, which were subsequently funded. The Malaysian project is currently investigating mass-production processes by injection-molding of plastics. This project will provide technical data for manufacture of 550 mass-produced models, all of which will be fabricated by a franchised local plastics manufacturer. These will be installed by the Ministry of Health, and their technical performance will be evaluated by the research team. Some experimentation will take place on the performance of this design in medium and deep wells. Also, important social, cultural and economic aspects essential to promoting acceptance of the technology and responsibility for maintaining the pump at the village level will be examined. The Government of Malaysia has expressed its commitment to the project by supporting all manufacturing costs.

The Sri Lanka project will concentrate on evaluating the feasibility of manufacturing their version of the pump through a network of cottage industries operated at the village level entirely by women. This research group will test the feasibility of involving primary users--women--in all aspects of handpump development, from manufacture to installation and maintenance. By promoting handpump manufacture as an income-generating activity, it is hoped that self-sustaining village-level industries can be established. It is also anticipated that the likelihood of keeping these pumps operational will be enhanced by locating the industries as close as possible to the sites where the pumps will be installed. Spare parts and technical expertise will be easily accessible--not always the case when manufacture takes place at large-scale centralized facilities.

The second round of IDRC-supported research includes projects in Malaysia, Sri Lanka, Thailand, Philippines, Ethiopia, Indonesia (under negotiation) and Costa Rica (under negotiation). Two research groups in India

have also expressed interest in the PVC pumps. These new projects will examine ways of promoting community acceptance, finance and maintenance schemes, and various community-based manufacturing options. In addition, low-cost well-drilling techniques will be investigated. In conjunction with this network of projects, a special project on support materials for handpump installation and maintenance (a manual designed for illiterate and semi-literate villagers) is being developed by PATH, the Program for Appropriate Technology in Health. Plans are presently underway with our Communications Division to produce a short video presentation on handpump operation, installation and maintenance for engineers and technicians interested in the technology. We also expect to release a film in 1985 that describes the IDRC approach from research and development (which began in 1976) to utilization.

As many international, national and private institutions and agencies (including IDRC) have embarked upon research and development programs to improve handpump designs, there is now an urgent need to assess the present knowledge, situation and trends in regard to handpump technology, and review and document the changes which have taken place. In response to this need, the IDRC, in collaboration with the International Reference Centre (IRC) in the Hague, the Netherlands, is engaged in publishing a monograph on the state-of-the-art in handpump technology (2).

The IDRC approach has been to encourage local researchers to experiment with a basic design and adapt it to local conditions with the materials available to them. In this way, we hope to promote the development of a true village-level operated and maintained (VLOM) pump. Rather than focusing on heavy-duty, medium- and deep-well designs and large-scale centralized commercial production, our program has emphasized simplicity, low cost and small-scale, decentralized manufacture. In addition, in keeping with the IDRC mandate, we are attempting to develop local expertise in all aspects of handpump technology, from experimentation to manufacture.

It must be remembered, however, that transferring a technology is not a simple case involving financial resources, trained experts and a good design. It also involves complex social, cultural, political, and economic considerations that are best--perhaps only--understood by the people themselves. Technology cannot be "parachuted in." It must be examined, tested, and modified according to local needs, available expertise and materials.

Finally, it must be pointed out that the basic Waterloo design is no better or worse than any other design. It is one of many technical options. In some communities, a pump with PVC components may be the answer, in others it may only serve as an interim technology until something better can be afforded. In still other communities, it may not be suitable at all. However, for the many millions of the world's rural population, PVC handpump technology is a beginning--a contribution to the Decade target of clean water for all by 1990.

For further information on IDRC's handpump research projects, contact the Health Sciences Division, Water Supply and Sanitation Section, IDRC, P.O. Box 8500, Ottawa, Ontario, Canada K1G 3H9.

(1) IDRC monograph: "Village Handpump Technology--Research and Evaluation in Asia" (IDRC - 204e, - 205f, - 204s). This document summarized the outcome of the end-of-project seminar held at the University of Malaya, Kuala Lumpur, Malaysia 16-19 August 1982. It includes technical information (performance characteristics) on each pump design, detailed drawings and specifications of the field testing program, some of the instruments developed for this purpose, and the results of a comparative economic analysis. This monograph is available in English, French and Spanish and can be obtained by writing to IDRC's Communications Division at the address above.

(2) The monograph is an update of the IRC Technical Paper No. 10 entitled "Handpumps," published in 1977. To gain first-hand information, an IDRC-sponsored consultant--a Malaysian National familiar with handpump research--is visiting ongoing handpump projects in Africa and Asia to observe and collect data for three chapters on current developments regarding maintenance, plastics and sociocultural and economic issues. In the spirit of collaboration, and to prevent duplication of efforts, the final draft of this document will be reviewed by World Bank experts and the author of the first publication, Dr. E. McJunkin. It is expected that a monograph will be released by late 1984.

UNICEF AND THE EXPERIENCE IN LOW-COST WATER SUPPLY AND SANITATION

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ABSTRACT

UNICEF, the United Nations Children's Fund, since 1949 has actively been involved in the cooperation with governments around the world for rural and peri-urban water supply projects to benefit the least-privileged populations. The scarcity of funds and many other constraints have prompted the use of low-cost technologies for reaching water sources, mainly groundwater and for water lift. This is carried out principally through handpumps, where there has been notable development during the last twenty years. This is now accelerated through cooperation with the UNDP/World Bank Interregional Handpump Testing and Development Project. Many of the previous experiences build on major government programmes and projects with UNICEF support on a large scale since 1969. One of the basic tenets of this work is to see the technological development and inputs as parts of an integrated approach, with a good balance between the technical and the social components, entirely oriented towards the users, involving their participation at all stages and with the necessary concern taken for their environment and handling of the equipment for the technical designs involved.

BACKGROUND, HISTORY AND POLICIES

UNICEF is the United Nations Children's Fund. As an autonomous body in the United Nations system, it has worked since 1946 for the improvement of the lives of children and mothers. Presently its activities cover the fields of child health, education, social welfare, nutrition and water and sanitation. UNICEF's mandate is to cooperate with governments in their programmes and projects. This work is carried out in some 120 developing countries in the world with a total annual budget of around 300 million US dollars. Of this total, the direct programme inputs are around 220 million dollars.

The funding of about 75 percent of this budget is provided on a voluntary basis by practically all the governments in the world. The remaining 25 percent are contributions from individual sources, the largest part being through National UNICEF Committees, which are active in many countries.

UNICEF has its headquarters in New York, with 140 offices around the world and a total staff of 3,000 persons, most of them in the field offices. These include about 140 specialists in water supply and sanitation in about 35 major project countries, with a small coordinating team of five professionals in New York.

The main thrust of UNICEF's work and policies is towards the improvement in health and development for children. The policies have gradually evolved in response to the actual needs and modified according to the practical field experiences. These have been successfully implemented, thanks partly to a considerable decentralisation of functions and responsibilities to the field offices, headed in each country by a UNICEF Representative and supported by seven regional offices.

The development of UNICEF policies did to some degree reflect the structure and mode of operation of most governments. Thus originally, much work was carried out sectorally on a project-by-project basis. During the mid-1960s, there was a purposeful shift in policies towards the promotion of basic services for children in an integrated way. In UNICEF's main task of advocacy for children, their health and well-being, it often failed to encourage governments to work at different levels in a more integrated, coordinated way between different ministries and agencies.

Lately, given the enormous needs to serve hundreds of millions of children annually with very limited funds, there has been a drive for specific cost-efficient measures to improve infant and child health under the headline of the "Child Survival and Development Revolution". This includes particularly the promotion and nationwide spread of breast-feeding (as opposed to bottle-feeding with infant formula), growth monitoring, oral rehydration treatment, immunization and other measures, including family spacing and female literacy.

Personal and food hygiene as underpinned by the provision of sufficient quantities of safe water and the installation of adequate sanitation facilities is one of the bases for the above action. Water and sanitation are part of UNICEF policies and activities since 1949. Up to 1969, most of UNICEF's inputs in this field consisted of contributions of equipment and material to relatively small demonstration projects for village water supply and sanitation.

In the year 1969, UNICEF's total input in water and sanitation worldwide amounted to only 2 million US dollars. A series of emergency situations, including the drought in Bihar and Orissa in India in 1966-67, the war of independence and the floods in Bangladesh in 1971-72, a flood in Pakistan and the major drought in the Sahel and other parts of Africa south of the Sahara, compelled UNICEF, following urgent government requests, to participate in an unprecedented way in the support of the poorest rural and peri-urban areas.

Very rapidly, this work increased, and in 1983, with a total expenditure of 63 million US dollars, UNICEF cooperated with 93 countries in their rural and peri-urban water supply and sanitation programmes. In that year, there were 12.9 million beneficiaries of the water supply systems and 2.8 million beneficiaries of installations for excreta disposal.

PROGRAMMING FOR LOW-COST WATER SUPPLY AND SANITATION

Until the end of the 1960s, much of work done especially for water supply and sanitation in rural areas, was approached as a public works activity, following purely technical concepts and targets. During the last fifteen

years, there has been widespread recognition of the needs to see water and sanitation as components of a wider health and development context.

What often happened in the old days was that water supply installations were made mostly with a relatively high degree of sophistication, requiring high technical skills and inputs in the form of costly energy and spare parts. The local populations would have no say in terms of whether they really wanted the installations, where they would be carried out and how they would be operated and maintained. Sanitation facilities were not even considered as they were not compatible with local beliefs, attitudes and behaviour. The results were frequently total failure of the water supply installations after a short time, and the objectives of improving people's health and well-being were not met.

This state of affairs led to considerable reappraisals of the situation and to more effective programme approaches. The main objectives of this form of activity is the improvement of health and socioeconomic conditions of the communities. These objectives have been better defined through intensified studies and research in a number of related fields over the last few years, including epidemiology, biomedical sciences, sociology and economy. This has led to seeing the need to deal with water and sanitation as components of a larger whole of development and, at the same time, to provide these services as a system and not just as technological items.

This affects the applications of technology and their use at the community level. The technology thus is part of the system and will have to be seen against the background of a number of factors, including the goals and targets set for each programme and project, including factors such as:

- * numbers in population and households to be served;
- * expected per capita consumption of water;
- * availability of water;
- * level of technical skills and learning capability in the communities;
- * funding sources available and potential financing capacity;
- * political interest and will for the support of the community-based work.

The users of water and sanitation facilities are thus the bases for all considerations to be made. The provision of any services to them necessitates an integrated approach. The proper balance has to be found between the technology and the social approach, or in other words, between the "hardware" and the "software". An indispensable element is the simultaneous engagement of the community, through its participation from the planning and programming phases of any project, through the construction to and including the operation and maintenance of the installations.

This requires a great deal of motivational and educational efforts, including sanitation and health education. The cost and time factors involved have to lead to a thoroughly elaborated plan, agreed upon between the implementing agencies and the community. This demands of the administrators,

planners and engineers that they would cooperate both with the community inhabitants, as well as coordinating with other agencies active at the community level, such as school, health and agricultural authorities.

THE TECHNOLOGIES--DEVELOPMENT AND APPLICATION

The general principles of what technologies to select and apply in the work of UNICEF with governments and a great number of other agencies, national and external, for low-cost water supply and sanitation, are most aptly summarized in the acronym "VLOM", as coined some years ago by the World Bank. This stands for Village-Level Operation and Maintenance. At least this concept can and should be upheld for any permanent installation.

The selection of technologies and systems is governed, again, by a number of factors, including those mentioned above. One important factor is the availability of water, where to find it and how large quantities may be produced without overtaxing the source. The projects supported by UNICEF, to the largest degree, draw from groundwater sources, since surface water either is not available or too contaminated to be dealt with other than with costly water treatment plants. In mountainous and hilly areas, natural springs are built and protected, mostly with connections through pipelines ("gravity-fed schemes") to villages. Most of the projects, however, are supplied through dug or drilled wells.

The question of the water resources increasingly requires proper knowledge through surveys of occurrence, characteristics and capacity. Over large areas of the world, there is too little or no previous knowledge of the groundwater resources in particular as well as no legislation, control or management. The result in many densely populated areas is overpumping, especially by larger agricultural, municipal or industrial units. This leads to a lowering of the water table, saline incursions in coastal areas and other occurrences detrimental to the adequate supply of fresh water. Apart from the concern for the direct amounts of water available to the poorer and poorest communities, this directly affects the technical design of the projects and the installations, including the water-lift facilities, i.e., pumps.

Brief mention should be made of the means to reach the water through digging or drilling. Water-well digging in less consolidated rock or soil formations may be a relatively simple matter for the communities to take care of themselves, given certain training of local craftsmen and workers. For many areas with harder formations or greater depths to the water-bearing formations, drilling is the only means to rapidly obtain coverage for the many communities.

This requires the use of mechanical or--under particularly easy hydrogeological conditions--hand-operated drilling equipment. There are four major sets of conditions met in several UNICEF-assisted project areas. These influence both the selection of drilling equipment, casing pipes and screens, and, to some extent, the pumps.

In the first case, the hard rock conditions, high-energy percussion and rotation methods have proven to be the most efficient methods. The last twenty years have seen a veritable technological revolution of machinery and

methods. The first large-scale involvement of UNICEF in village water programmes anywhere in the world was in India from 1970 onwards, with the use of down-the-hole hammer machines with hydraulic rotation heads. This now permits the drilling of a well in hard crystalline rocks, such as granites, gneisses or basalts, to an average depth of 50 metres in an eight-hour shift. The efficiency can be contrasted to the time it took with the locally available cable-tool rigs twenty years ago. They required up to three or four months to achieve the same results.

The second group of well-drilling conditions is in coarse-particle, gravel or boulder formations. So far, cable tool drilling with heavy equipment is predominant, although the recent development of heavy polymer drill foam additives may make it possible to use more rapid down-the-hole hammers, aided by special tools in some places. This type of work, for example, is carried out in the mountain valleys of Pakistan and India.

The third group consists of partial to relatively consolidated formations that are not as hard or abrasive as crystalline rocks. This group is comprised primarily of sedimentary rocks. In this case, straight mud rotary or other forms of rotational drilling would be used. The dry central zone of Burma is a good example of such activities and is supported jointly by UNICEF and the Government of Australia.

The fourth group is soft, unconsolidated formations with the water table close to the surface, where a screen with the attached pipe ("rising main") can be pushed into the ground by hand. There are ways to do so by hammering down well-points or using the "sludger" method where a galvanized iron pipe is lowered into the ground through pumping or "sludging" it down by hand. This is practiced in the low-lying silts and sands of the Ganges and Brahmaputra valley plains and deltas in Bangladesh, India and Nepal, where the work is rapidly carried out by local well sinking teams. Another method done by hand or with simple engines and akin to the sludging is the common jet drilling, used for depths to 300 metres in the coastal areas of Bangladesh to reach fresh water aquifers.

The implementation of the well drilling or digging for the construction and installation in the wells has direct bearing on the expected span of life of the facility and on the quality of the water rising up to the spout or the tap. Proper isolation of the well from the surface, the selection of casing and screens, the use of gravel-pack or pre-pack filters all contribute to the way in which a well would serve the community.

The water lift in the large majority of UNICEF-supported rural, as well as in many urban or peri-urban water supply projects is provided through handpumps. A handpumps-based system is the simplest, least expensive method of lifting water out of the ground, as well as the easiest to operate and maintain. UNICEF probably is the single largest handpump buyer in the world. Given the limited interest and experience twenty years ago in handpump use and technology, most handpumps available around 1970 were the traditional cast-iron types, designed a century or more ago and intended for use by single farm households.

Most handpump schemes until then were unsuccessful, since none of the handpumps could stand up to being used daily by hundreds of individual users

and were subject to abuse, intentional as well as unintentional. There was a need to develop new designs, as well as to make the communities aware that the operation and maintenance was their responsibility, that the handpumps belonged to them and that they really could reap considerable benefit from their proper use and upkeep.

The results were a gradual acceptance of both new social and technical concepts and domestic handpump usage spreading nationwide in countries such as India and Bangladesh. In the latter country, hundreds of thousands of small, inexpensive suction-mode pumps are used also for micro-irrigation purposes, allowing farmers in the areas above the high-water mark, i.e., not reached by the yearly floods, to produce an additional crop during the dry season.

The great need for sturdy, low-cost, VLOM-type handpumps, prompted UNICEF water supply specialists, jointly with national engineers and manufacturers in India and Bangladesh, to look for and further develop designs which would stand up to the hard requirements. The result was the development in India of the India Mark II deep-set (lift-mode) handpump out of the "Jalna" and the "Sholapur" pumps. (A more detailed account of this is given in the annex, "Water Innovation--A Case Study: The India Mark II Handpump".)

Similarly, in Bangladesh, the "New No. 6" handpump was developed as an improvement of the locally manufactured cast-iron suction-mode pumps for manufacturing on a widely expanded scale by local foundries. In other countries, locally manufactured pumps were accepted for procurement and installation. Such pumps include the Korat handpump in Thailand; the "Dragon" type pump, originally a Japanese design; in Indonesia; and the Maldev pump in Malawi.

The further ongoing development of even simpler and better operational and maintainable designs aimed at the very same project areas, particularly as prompted through the UNDP/World Bank Interregional Handpump Testing and Development Project, is not only being followed by UNICEF with great interest, but the field tests and essential new developments take place with direct UNICEF participation (which will be taken up in the conclusion of the present paper).

The next steps in project implementation and in the actual process of providing water to the users are those of transport and storage of the water up to its end use. There are still major gaps in many programmes. In nearly all cases of handpump water supply, people have to carry the water to their homes, women and children bearing the main burden. There are areas so poor that the families cannot afford even to buy proper water vessels to transport and store their daily requirements of water. There are practices during the pumping, transport and storage which increase the risk of contamination of the water, even if it comes out reasonably uncontaminated from the pump spouts. This is still a large field for research and development, which would need to be coordinated with the ongoing handpump development and with the ongoing mass implementation in the field.

Operation and maintenance had to be built up from scratch in all project areas. The most massive experiences again are from India and Bangladesh. So far, the establishment and upkeep of a workable maintenance system is far behind the rate of installation of handpumps. As of the beginning of 1984, in

the State of Andhra Pradesh (India) alone, some 86,000 India Mark II handpumps have been installed (and reported to be functioning in over 80 percent of the sites) since 1976. Yet there are still no more than 6,000 "handpump caretakers", local villagers trained in their maintenance.

On the other hand, a beginning has been made, and the Indian model is being replicated in other countries as well, such as Sudan and Sri Lanka. There are major benefits and good side effects of the training of villagers. They clearly accept the work of the local authorities to promote their activities. Furthermore, the brief two- or three-day training courses provide them with intense health promotion, as well as an opportunity, for the first time in the lives of many of them, to meet with fellow villagers from other parts of the same state and to share joint problems and issues with them, often in matters beyond a mere handpump. It is thus often a departure point for local political involvement in a positive and constructive vein for an exposure to new ideas and concepts, not the least of which are in community matters such as health, education and other basic services.

The need for an integration of the technological concepts with those of health and socioeconomic concerns have already been mentioned. This has its direct implication for the overall planning and management of the programmes and projects. The economical considerations are strong determinators for both the initial investment (capital costs) and the costs for operation, maintenance and repair. Total annual costs should be calculated on the basis of amortization, since a replacement or thorough renewal of the installations will sometimes need to be made.

It is difficult to provide any exact figures for this cost factor, but certain indications may be made. Currently, the most up-to-date and detailed costing available is from the hard rock wells with the installation of India Mark II handpumps in India:

Given the average depth of 50 metres,
a well diameter of 4 to 6 inches,
one handpump per 200 inhabitants,
an expected life length of the well of 20 years,
an expected life of the handpump of 10 years,

the overall cost of the water supply is distributed as follows:

	<u>US dollars</u>
Drilling of the well 1500
India Mark II handpump 200
Platform and drainage 100
TOTAL 1800

Investment per capita US\$7 -

Maintenance per handpump per year	US \$35
Maintenance per handpump per capita per year	0.14

Total cost of water per capita per year for
5 - 10 gallons (20 - 30 litres) per capita per day: US\$0.56

Correspondingly, the costs for the "shallow tubewells" in Bangladesh are considerably lower, with a total cost per installation of about 200 US dollars.

SPREAD OF THE TECHNOLOGIES--FURTHER DEVELOPMENTS

An important part of UNICEF's joint work with other agencies and bodies of the United Nations system is the encouragement of country- and community-based activities under the framework of the International Drinking Water Supply and Sanitation Decade (1981-1990). The further development and spread of the use of adequate or "appropriate" technologies is a most important part of this work. One of the functions of the international system, including individual governments, research institutions and training facilities, is the collection and dissemination of technical information and experiences.

For the most effective use of funds available for water supply and sanitation, it is always necessary to be a step ahead in technical development in order to serve the users of water and sanitation facilities more efficiently. For this purpose, the collaboration between UNICEF and the UNDP/World Bank Interregional Handpump Testing and Development Project is probably one of the most important and beneficial ventures currently going on.

The new developments of the down-hole parts of the India Mark II handpump and the smaller, lift-mode "Tara" handpump in Bangladesh, with their lightweight and easy to operate, maintain and repair PVC plastic components, are especially crucial for all organisations involved to meet the continued demands and needs to supply fresh water at low cost and manageable levels for the communities--in the long run for at least another billion of inhabitants of our globe.

These demands are still beyond the present capacities of governments and external organisations alike. This is a major challenge, and none less than a question of survival for our fellow men, women and children in more than half of the world. At the same time, it is a great chance in a modest way to improve the quality of life by facilitating a number of basic health measures and to make other social services a reality.

ANNEX. WATER INNOVATION--A CASE STUDY: THE INDIA MARK II HANDPUMP

Summary

In the field of water supply and environmental sanitation for communities in the developing countries where the needs for low-cost technological solutions are paired with an appropriate social approach involving community participation, motivation and education, there are many innovations. Few, however, are clear-cut examples of a "one-shot" success. Most are the result of an evolution, often coming about over decades or even longer periods.

The India Mark II handpump, widely used and accepted in India and increasingly in other parts of the world, may illustrate several aspects of the interlinked technical and social development of one seemingly simple and yet so complicated item.

The present paper presents the pump in its present technical design, traces its history since the great droughts in eastern-central India in 1966-67, and discusses its manufacture, marketing and use. It gives an overview of some of the social problems involved, particularly those of operation and maintenance, ending with future trends in design and the reassurance that handpumps and inventors dealing with handpumps have a future!

What is an Innovation?

Yes, what is an innovation, really? And what is it in the field of water and sanitation, where technical responses to the acute needs of communities and individuals have evolved through the hundreds and thousands of years in the past?

There are many innovations in this field--not necessarily of the basic technologies but in the applications. Our concern is especially for their use in the service of the underprivileged and underserved millions of people in the poorest areas of the developing countries.

In the present context, an innovation is seen as a new technical and methodological concept, taking physical shape as an implement or a tool. It should fill an evident need, be effective and economical, and be replicable and marketable, i.e. accepted for general use by a broad public.

There are quite a few innovations of sorts in the area of low-cost water supply and sanitation which have been brought into good use during the last twenty years. Few cases are clear-cut innovations. Most of them are rather the result of several years or decades of evolution. This may have been a slow and gradual process or arrived at in leaps and bounds.

One of the few clear-cut innovations known to this writer is the VIP (Ventilated Improved Pit) latrine, a recent and most successful development from the Blair Research Institute in Harare, Zimbabwe. Even the originator can be pinpointed in this case--Dr. Peter Morgan.

Since the discussion around the International Inventors' Award so far is concentrating on water, however, it seems that more directly water-related items would be more suitable for the present case.

Again, of all technical items, it seems that handpumps may be singled out. This deceptively simple item, in fact, is the only hope for millions of people to obtain potable water from groundwater sources reasonably close to their home.

While only twenty-five years ago, most handpumps in the world were of the traditional cast-iron type with reciprocating action in a pump cylinder-- either of a suction mode (water table at a maximum depth at sea-level of 7 metres) or of a lift mode (with a pump cylinder set at water depths below 7 metres, i.e. the cylinder well below the water table), there are now many improvements in the principles and designs.

The most frequently used models still follow the reciprocating principle, but there are other, new mechanisms under development or in the market. Among them, a few could be mentioned as examples:

- The Mono and Moyno pumps with spiral stainless steel rotors in a rubber housing in the pump cylinder (Inventor: M. Moineau, France, about 1925);
- The "hydropompe Vergnet", a pedal-operated pump with hydraulic action on an inflatable silicon rubber bag inside the pump cylinder, developed by two French engineers, Messrs. Vergnet and Benamour at the Centre Inter-Etats pour les Etudes Hydrauliques in Ouagadougou, Upper Volta, during the early 1970s;
- The "PETRO" pump, a positive displacement pump with a rubber hose anchored in the borehole walls below the water table at the lower end of a small diameter rising main (pipe). By raising and lowering the pipe through a hand lever at the surface, the rubber hose section narrows and extends, displacing the water upwards with a simple arrangement of two ball valves at either end of the rubber hose. This was invented during the mid-1970s by a team of one Swedish engineer, Jan-Olof Persson and one Norwegian engineer, Per Fredrik Trøften;
- The "PULSA-3" pump, which is a brand new development, a diaphragm pump with a reportedly easy flow of handpumped water through an oscillation phenomenon. It has recently been developed and is now being marketed by an Italian company, Fluxinos, in Milano.

There are quite a few other pumps available for consideration as useful innovations. An important activity underway since the late 1970s, originated by the Overseas Development Agency of the United Kingdom and continued on a much larger scale with laboratory and field tests, is the UNDP Global Project for Handpump Testing and Development, managed by the World Bank (Project Manager: Mr. Saul Arlosoroff).

This project deserves particular mention. It is the first attempt to not only test and compare, but also stimulate further development, including the improvement of handpump models presently being built and marketed in the

developing countries. A notable feature of the project is the involvement of social scientists in the field-testing phase, which recently began in some twenty-five countries around the world. The interaction between technical and social factors in terms of design, acceptability and use of pumps--handpumps--is now fully recognized. This is not limited to just ergonomic parameters. The attitudes to participation in the installation, operation, care and maintenance of the pumps vary greatly from population to population, even from community to community.

For the present case study, none of the above pumps, however ingenious they might be, has been selected. Instead, the subject of the presentation is the "India Mark II" handpump.

Why the India Mark II Handpump?

This device incorporates in its design quite a variety of innovative features. It is--at least in the above-ground pumpstand--the best accepted handpump in India, in use in its present form since about 1976. It was developed in a "developing" country. Accepted in India, it is now being manufactured and marketed throughout the whole country. There is an incipient transfer of this pump to other countries and parts of the world.

This does not imply that the India Mark II handpump is the one and only pump feasible, useful and available. Several other good designs and models do exist and are being used, including such analogous types as the MALDEV pump, manufactured and installed in Malawi and Zimbabwe.

Neither does it imply that the India Mark II design is unusual or the final pump design, as we shall see in the following.

The India Mark II, nevertheless, was an innovation for several years, being one of the first widely used handpumps to be called a VLOM-type pump--fit for Village-Level Operation and Maintenance--by the World Bank (Arlosoroff). That, and the many problems and solutions of a technical, social, financial and administrative nature surrounding the introduction, spread and upkeep of the India Mark II pumps, constitute quite an unusual experience. We have learned many lessons from it, and the learning process will probably not cease for another hundred years or so.

Technical Description of the India Mark II Handpump

Among the main features of the handpump is the pumphead with its handle above the ground, anchored to a pump platform or the lid of a dug well. The other parts of the pump reaching into the water source--normally a drilled or a dug well--are the rising main (mostly a 1 1/2- or 2-inch pipe) and the pump cylinder. The cylinder contains a pump piston with a leather washer, connected to the handle with pump rods and connected with each other through threaded joints.

The interesting part of the existing and presently manufactured version of the India Mark II is the pumpstand. No less interesting is what goes into the water. The present design, however, is conventional. (The down-the-hole parts will be discussed in a later section.

The first innovative feature, at least for India, was the concept of using mild steel instead of cast iron for the pumphead. Among the many problems with old-type handpumps was the brittleness of cast iron. It can easily be envisaged, with the (understandable) habit of water buffaloes to scrub their flanks against any solitary standing angular object, what the improvement in materials may mean.

Another feature was the body being designed so it could be taken apart for maintenance. Also the pumphead could be separated from the rest of the stand. One idea behind this was the possibility of rehabilitating old pumpstands by just replacing the head, although this practice was discontinued after some years in favour of installing entirely new pumps.

The setting of the pump in the concrete platform after placing the lower part of the stand made of standard steel pipe over approximately two feet of casing pipe left to protect the borehole is done by firmly encasing the three legs in the concrete. This does away with the all too frequent occurrence of screwing a pump's bottom flanges onto bolts in the platform. Invariably this arrangement leads to a loosening of the pumphead, a major cause for the demise of handpumps.

The angular spout is designed to prevent vandalism, e.g., by small children throwing stones or pushing sticks up the orifice. Likewise the design of the only other orifice or opening of the pumphead, the entrance point of the handle, was designed so as to prevent, to the degree possible, people and especially children from getting their fingers mauled.

Painting the inner part of the pumpstand with resin protects it from corrosion by aggressive waters. An outside coat of paint likewise is good protection.

The handle with its square crosscut, likewise made of steel, is good insurance against another common cause of handpump breakdowns--the snapping of handles, so as to say, in midstream. A particularly interesting part of the design--one of the innovations for a handpump--is the circle-segment inner end of the handle. This facilitates a smoother and better centered transfer of the up-and-down movement between handle and pump rods with a sturdy motorcycle-type chain, assuring a flexible link between the handle and the rods.

The movement of the handle is eased by two standard ball bearings taking up the movement of the central axle.

A detachable cover allows for easy inspection and greasing of the handle end and chain. Other design features inside the central pump chamber ensure that no backwash or potentially contaminated matter from the outside can enter the pump or the borewell.

The connecting rods and cylinder are standard items. The rods are circular steel rods. The cylinder is a steel cylinder, brass-lined with leather or PVC buckets and two valves, one in the plunger (piston) and one check valve at the cylinder bottom.

The present (summer/Northern hemisphere/1983) price ex-factory of the India Mark II pump is about US\$350 including stand, cylinder, rods and rising main (riser pipe) of 30 metres galvanized iron (1 1/2 inch).

History of the Mark II Development

It all started with the catastrophic drought in the eastern Indian States of Bihar and Orissa back in 1966-67. The human suffering caused by this drought in the hard-rock areas of central and eastern India prompted the use of high-technology advanced and rapid drilling equipment to reach groundwater that sank way out of reach to the villagers. The villagers, therefore, could no longer rely on their large, costly and shallow open wells (which were also badly contaminated when there was water in them during the monsoon period).

The first groups to use such new and imported drilling equipment were single, relatively small voluntary organisations, such as the New Delhi-based Action for Food Programme (AFPRO). Their funding limitations notwithstanding, AFPRO in particular was well-equipped, well-managed and spirited, and not only pioneered much of the use of drilling equipment--as far as is known to the present author--but also originated the principal ideas behind the pump, which gradually at a later stage was transformed into the India Mark II handpump.

The original AFPRO version was the so-called Jalna pump, which already contained most of the innovative elements: the steel body, the steel handle, and the circle-segment cum chain.

A further step was taken by the Sholapur Mission in southern Maharashtra, southeast of Bombay, where an expatriate Swedish engineer, Oscar Carlsson, took up the idea from AFPRO, converted their short, squat conical pumpstand into the steel-pipe type and constructed a pumphead, which basically looked like the present one of the Mark II. This version was called the Sholapur Pump and was mainly used in the water-well drilling and pump installation activities of the Sholapur Mission.

When, based on the experiences from the emergency relief action during the Bihar and Orissa drought, the Government of India in 1968 requested UNICEF to make a major contribution to a newly conceived village water supply programme in the "hard-rock" areas of India, UNICEF's input was mainly to be in the form of a great number of air hammer drill rigs. This technology, then relatively new for water wells, allows a water well of the standard depth of 50 metres (150 feet) to be drilled within one eight-hour shift.

The best that could then be achieved with the locally manufactured conventional cable tool rigs in the same granites, gneisses and basaltic lavas was one 50-metre well of a four- or six-inch diameter produced in two to four months.

This was quite a revolution in technology. At that stage, when the India Village Water Programme began to be implemented around 1970, the high speed of the drilling equipment was more commensurate to the tremendous needs of villages to be supplied. Out of the total of some 650,000 villages in rural India, 250,000 were in great need of basic services, not only in water supply and sanitation, but also in sectors such as health services and education. Of these, 125,000 villages were officially classified as "minimum needs

villages". The lack of access to adequate quantities of safe, fresh water within easy reach of the villages strongly contributed to a dismal health picture, malnutrition, high infant and child mortality and morbidity (disease rate), and social stagnation, with the particular problems still associated in many places with the caste system and the "harijans", the casteless people.

The new drill rigs solved part of the problem, only to lead to the next one, the handpumps. To begin with, locally manufactured pumps, then commercially available, were installed through the State Departments of Public Health Engineering, then the principal government agencies responsible for the programme.

In 1973, reports began to arrive from the villages that the handpumps were broken down. In certain areas, the estimates of the number of pumps out of order were quoted as exceeding 80 percent! Something had to be done and quickly!

The result was a far more elaborate approach than had in all original innocence been envisaged from the beginning. Recognizing the problem, a unique cooperation between the Government of India, through its Ministry of Housing, the state governments, and UNICEF, with the help of the engineers of MERADO (the Indian Government Mechanical Research and Development Organisation) and the Government of India-owned steel construction firm Richardson & Cruddas in Madras began and built an approach, which at this state- and countrywide scale in 1974-76, was quite unprecedented anywhere in the world (possibly with the exception of Bangladesh with the spread of the shallow-well, suction-type, cast-iron "New No. 6" handpump, but that is another, albeit successful, story).

The problems of selection and further development of pump design was one matter, solved by adopting, testing and refining the Sholapur, ex-Jalna pumps. With good skills and enthusiasm on all sides, an extensive laboratory testing procedure at MERADO, the manufacturing and marketing concerns of the Richardson & Cruddas management and engineers, and a field test of twelve prototype pumps around Coimbatore, the new pump took shape and, so as to imply its national significance, was honoured with the name of "India". The "Mark II" designation remained from passing a first Mark I stage during the early phases of development.

The major problem now was to have the pump manufactured in sufficient numbers, installed in this giant programme, accepted and largely maintained and repaired by the villagers, with some support from the state governments. The history of the Mark II is one of two aspects: the technical and the social development. Before going into the social aspects, some notes may be made of the extent of present manufacture and marketing of the India Mark II handpump. Its history still is in its beginnings and there are major changes ahead.

Manufacture and Marketing of the India Mark II

When the present design was finalized, and manufacture and installation of the pumps had begun, an assembly of government engineers and administrators from all over India decided to agree on design standards for the pump and to incorporate and codify them as Government of India standards. An easily

understood rationale for this, among others, was the need for true standardisation, so as to ensure uniform quality and to facilitate the manufacture, logistics, distribution and use of spare parts.

It should be noted that there are no patents covering the design or any details of it--this would not be realistic and would be contrary to the humanitarian concerns behind the whole idea.

Some years ago, there were twenty-two registered manufacturers of the India Mark II in India alone. Some of the larger ones use subcontractors, many of them literally cottage industries, for the manufacture of single components. In a modest way, this development has contributed to creating new job opportunities and a spread of skills. A subsidiary branch is the manufacture of spare parts and tools for the maintenance and repair of the pumps.

The present manufacturing capacity in India may well be around 80,000 handpumps per year or more. Interest has been reported in establishing further manufacturers from practically every state in India, partly as a result of the State authorities preferring to buy locally, and possibly as an indication of an increase in privately installed wells.

In the meantime, the India Mark II handpump has spread to several other countries, partly by procurement through UNICEF and other external organisations and partly through a combination of local government and commercial interests. A small-scale local manufacture of pumpheads was even started some years ago at the UNICEF-supported workshop for rural water wells in Wau, Bahr-el-Ghazal Province, Southern Sudan. A joint India-Togo venture is planning to begin manufacture in Lome, Togo (with INALSA, New Delhi), and a German manufacturer, Pumpenboese A.G., is now marketing the Mark II under the name of the "pb pump".

In India, UNICEF probably still is the largest single customer for Mark II pumps, although it appears that more and more procurement is done directly by the state governments. The standardization of the pumps has been a good help for ensuring uniform design and interchangeability. Strict and continuous control of manufacturing and deliveries by UNICEF, using Crown Agents, also helps to maintain good quality, contributing to the increase in longevity and usefulness to the villagers.

The India Mark II Handpump in the India Village Water Supply Programme-- Social Factors in the Acceptance, Operation and Maintenance

The magnitude of the problem of supplying hundreds of thousands of villages with potable water already was indicated by the figure of 125,000 "minimum needs villages". This gets more serious when one realizes that these villages frequently have populations of 1,000 to more than 3,000 inhabitants each.

The continuing problems are further illustrated by the fact that even now, with some estimated 600-800 high-speed drilling rigs operating all over the hard rock areas under government supervision, the maximum number of inhabitants per handpump who can obtain an effective supply of safe water is estimated at 250 persons. More people using the pumps would imply smaller

quantities of water (and for reaching the health objectives, the quantity of water is as important as the quality), more time wasted in queuing up at the pump and greater wear on the pump. (The "patience" of the India Mark II is attested by the Dinka people in Southern Sudan, who call it the "Donkey Pump").

There are many barriers to overcome. Among them is the general lack of health awareness and knowledge of simple means to preserve and protect health, especially that of children (including such measures of simple treatment of diarrhoea as oral rehydration salts dissolved in water and the requirement of safe water from handpumps).

There are other barriers, invisible to the occasional visitor, which have nothing to do with the technology. Landholding and economic and social power in the hands of single individuals may affect the selection and location of the pump sites, which in turn may lead to undue control over the use of the pump.

Likewise, there may be a need for installing separate pumps, e.g., for the casteless families--the "harijans"--who in many cases in the countryside are still kept outside the rest of the village societies, despite continuous efforts by the Government of India to even out the differences and discriminations of the population.

Technical problems are linked to the degree of understanding of and education in health problems, such as the need for proper platforms and drainage. The lot of women can be considerably improved by supplying an extra bag of cement for a laundry slab.

The acceptance by the local users, who traditionally are mainly women and children, can be seriously hampered through mistakes in the installation or deep setting of the pump cylinder, causing an increased weight on the handle. This can be counterbalanced by adding iron bars or other heavy items to the handle.

The main problem, though, remains the maintenance and repair of the pumps. For a number of years now, a maintenance organisation called the "Three-Tier System" has been spread throughout India and replicated in other countries. It was first instituted and tried by the Tamil Nadu Water and Drainage Board in Southern India under the able coordination of the Deputy Director for Rural Development of Tamil Nadu, Mr. Francis, using his experience in organising agricultural extension work.

The result was a mutually supportive system, based on community participation, with a strong element of motivation and education seconded by the District Development Officers. The three tiers of the system are as follows:

Village Level:

In each village, a "handpump caretaker" is selected from among the villagers themselves and given a brief but intense training in health education, maintenance and simple repairs of the handpumps usually by the District

Development Officers or by technicians from the state authorities. The caretakers are provided with a set of simple maintenance tools and a diploma as formal manifestation of their new responsibility.

Block (subdistrict) level:

A roving mechanic supplied with a set of tools and a bicycle or a motor-bicycle is employed by the state authorities and makes regular rounds to about 100 handpumps allotted to his supervision. His task is to inspect the state of the pumps and to help the villagers with simpler repairs.

District level:

Water authority maintenance teams with a truck (lorry), equipped with a tripod and heavier tools, are employed to carry out major repairs beyond the capacity of the other two tiers. Inasmuch as the block mechanic would not be available immediately to report major repair needs, the village caretakers are provided with preprinted postcards with a simple line-drawing of the Mark II handpump on which they can circle the parts needing repair.

One aspect that always is being considered in development programmes and projects is the opportunity for the advancement of women. The involvement of women in handpump projects does provide interesting possibilities. As of this writing, the present writer is not familiar with the actual situation in India, although indications are that the overwhelming number of the caretakers are still men.

In other countries, women are beginning to make modest inroads by increasingly being given training in handpump maintenance. This is the case, for example, in Bolivia and, more recently, in Bangladesh. The new responsibility and the simple mechanical training may be a first step towards an improved status in their communities and further relief from their drudgery, one of the capital hindrances on the road towards women's real liberation.

Where is the Mark II Headed?

At present, there are signals from India of apprehensions for the future of the village water programme with the India Mark II handpumps--unless there are changes, including potential innovations.

With the yearly installation of tens of thousands of new handpumps and with hundreds of thousands already in use (many for seven or eight years now) the existing maintenance system is getting more and more stretched and costly.

There are no exact costs available for the upkeep of the Mark II pump, or any handpump in the world for that matter. The World Bank has recently begun a study (originally under Mr. Nicholas Burnett, now under Mr. Edward Quicke) of the economics of handpump use. Even so, there are so many intangibles, including the cost/benefit from the health and socioeconomic impact, as well as hidden costs, e.g. government administration, that probably even a qualified economist would have to use quite a deal of guesswork.

Estimates, however, of the maintenance costs for one single Mark II pump per year recently have been put between US\$35 all the way to \$200. A cost as low as \$35 is still high for poor villages and financially constrained government authorities. The cost for the district maintenance teams with their trucks and fuel requirements increases with the number of pumps installed.

There is again a need for changes in the programme. For the moment, the most immediate change is for a redesign of the pump, notably the parts going into the wells. The present design requires that the entire length of riser pipe be withdrawn, together with the cylinder and pump rods, for a maintenance measure as elementary as the change of the leather cups or washers.

This operation takes place once every six months and sometimes more frequently. It virtually requires the help of the district maintenance team--truck, tripod and all--every time. The major constraint of this type of work can only be improved through a radically new design of the whole down-the-hole assembly.

Such development is presently being undertaken in a well-coordinated manner in India and Bangladesh, actively supported and advised by World Bank and UNICEF specialists. The aim is to arrive at materials and designs that would allow the villagers to be practically autonomous in their maintenance and repairs of the pump.

The present redesign, testing and further development involve plastic materials that are locally produced. It allows for retrieval of all down-the-hole components without any special lifting tools whatsoever. The individual details with their spare parts should be able to be manufactured locally and made available through the village tradesmen.

This is all work of high urgency, but as with most innovations, these changes will take time before they are perfected, standardised, agreed upon and brought into manufacture, distribution and use. The work on the present "Bangladesh Mark I" no doubt will be of great benefit to a future "India Mark III" handpump.

Is There a Future in Handpumps: Should Inventors Bother with Handpumps?

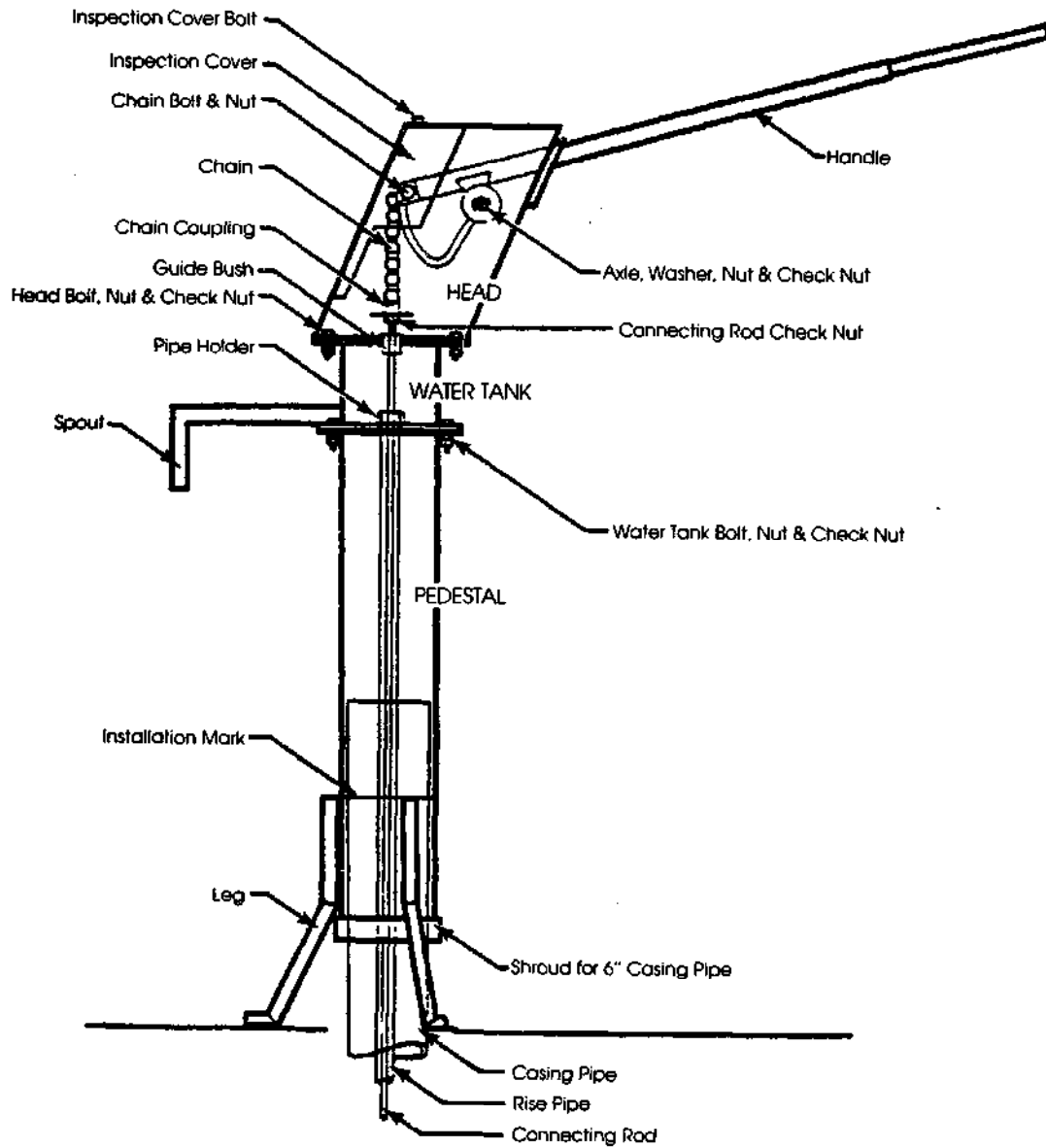
Both questions quite easily should be answered with a resounding "yes"!

There is a future in handpumps; if the goals of the International Drinking Water Supply and Sanitation Decade of 1981-1990 are to be reached--with little likelihood of a 100 percent fulfillment, but a potential for reaching quite a number on the way--handpumps, for at least half of the now 2 billion people in need, are probably the only way to provide the most elementary services.

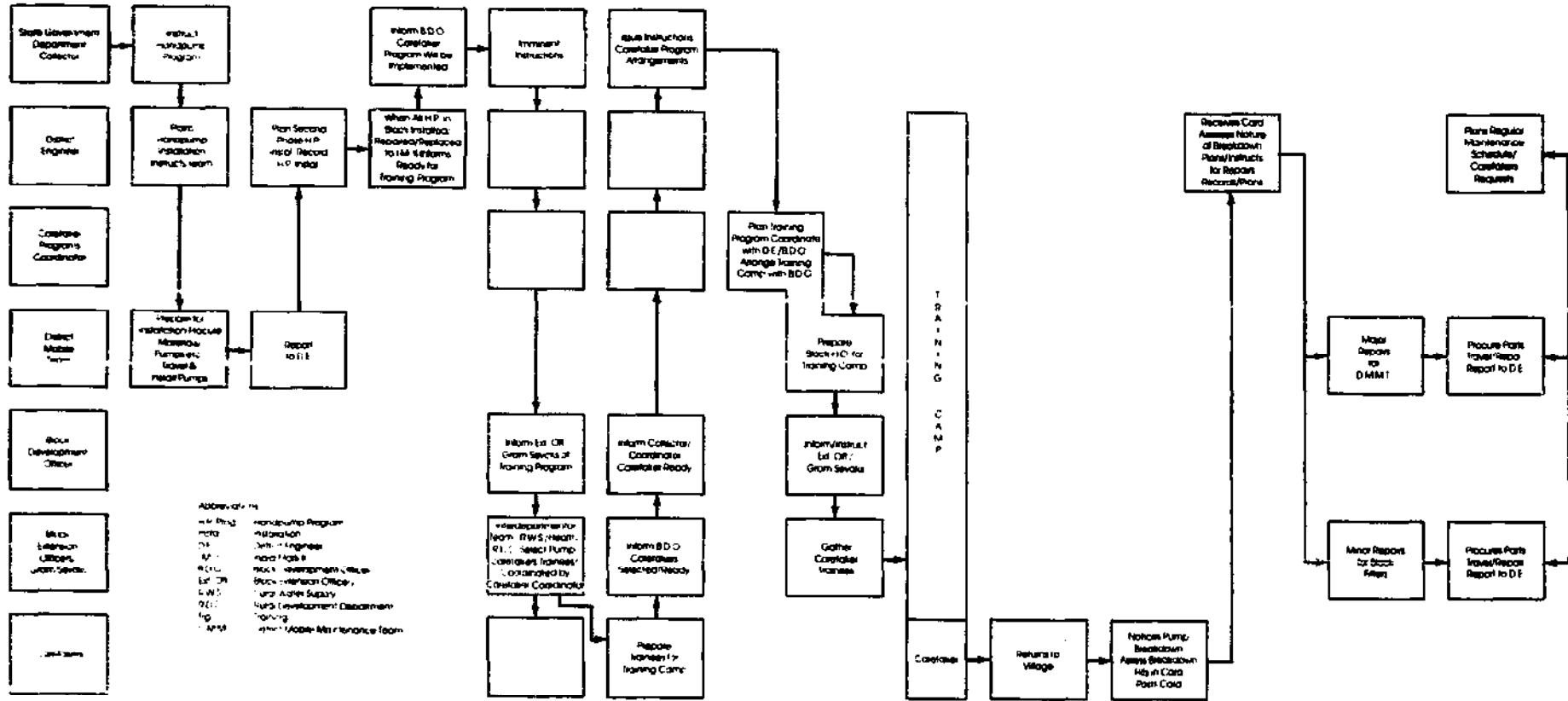
A further aspect is the fact that with the great scarcity and vulnerability of groundwater resources in many densely populated areas, handpumps do not deplete these resources in the same way as power pumps do when the pumping is not controlled.

As for the second question, inventors should and do bother about handpumps. There is a surge in interest, both from a humanitarian and a commercial point of view, prompting a good deal of inventive thinking and development. Any motivation and approach is valid, as long as the basic objectives remain clear: the acceptance by and usefulness to the water users.

India Mark-II Handpump



Handpump Rejuvenation and Maintenance Program Organogram



Abbreviations:
 H.P. Handpump
 I.E. District Engineer
 C. Control Region's Coordinator
 D.M.T. District Mobile Team
 S.D.O. State Development Officer
 G.S. Gram Service
 P.T.P. Plan Training Program
 T.C. Training Camp
 R.V. Return to Village
 N.P.B. Notice Pump Breakdown
 R.C. Receive Card
 I.I.C. Issue Instructions
 P.M.S. Plan Regular Maintenance Schedule
 M.R. Minor Report
 P.P.R. Procure Parts Report
 M.M.T. Mobil Report to D.M.T.

A BRIEF HISTORY OF THE INDIA MARK II HANDPUMP

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During the first four years of the Water Decade, the India Mark II handpump has become one of the most popular handpumps in use in Asia and Africa. The widespread adoption of the India Mark II has led to its mention in various development journals. However, several of these articles have generated some misunderstanding and incorrect information as to the origin and use of the pump. This paper has been written to at least attempt to set the record straight with regard to the origin and development of the India Mark II.

HANDPUMP EVOLUTION IN INDIA

The India Mark II story really begins in 1967 with a chance remark from an Indian government official who said to an English missionary in Jalna, Maharashtra, "I like your wells, but I don't like your pumps!"

In the early 1960s, the Jalna-based Church of Scotland's "War on Want" mission introduced air rotary drilling rigs for drilling wells for drinking water in the hard basalt formations of Maharashtra. While drilling was fast with these machines, the handpumps fitted to the bore wells were of poor quality; locally manufactured cast-iron copies of European and American handpumps which were meant for family rather than community use broke down frequently.

By the end of the 1960s, the Jalna project had developed an all-steel handpump whose principal feature was a single-pivot handle instead of the multipivot handle of the cast-iron pump. The handle pivot incorporated a water pump bearing (of a truck) attached to a quadrant over which ran a link chain joined to the connecting rods; this ensured proper alignment and the rods remained in tension at all times (no reversal of stresses), thereby prolonging rod life. These pumps were a great advance over anything yet tried in India and, within a few years, hundreds of the "little yellow handpumps" could be seen in the villages of Maharashtra.

Soon after, the American Marathi Mission project at Wadala, also in Maharashtra, picked up the Jalna design and improved upon it. This became known as the Jalwad pump. Although the design was almost the same, it was more accurately made and also more durable than the Jalna pump. These two

pumps quickly established themselves and proved to be a vast improvement over the cast-iron models produced elsewhere in India; soon, demand far exceeded supply.

In the early 1970s, the Sholapur Well Service (funded by the Swedish Covenant Church and located in Sholapur, Maharashtra), designed a handpump that was similar in many ways to the Jalna pump. However, the Sholapur pump was more professionally engineered, accurately manufactured on jigs and fixtures for uniformity, and contained a completely new pivot mechanism which cleverly avoided lateral stressing of the bearings--the key to long-term bearing life on the India Mark II. The Sholapur pump incorporated two additional features which are retained on the India Mark II: a roller chain which operates over a quadrant (similar in concept to the Jalna pump) and a pedestal which fits over the borewell casing pipe to help ensure an effective sanitary seal.

Other Maharashtra-based mission projects under the auspices of AFARM (Action for Agricultural Renewal in Maharashtra) copied the Sholapur design; however, without standardised drawings each pump was different and interchangeability of parts was impossible. By 1974, several thousand Jalna, Jalwad and Sholapur pumps had been installed, principally in Maharashtra, but as yet, there was no thought of introducing these pumps on a large scale elsewhere in India. It was primarily a question of the mission projects manufacturing sufficient pumps for wells drilled by their own drilling rigs. However, copies of these improved pumps began to appear in neighbouring states.

Also in 1974, UNICEF carried out a spot survey in Tamil Nadu to determine the status of the bore wells drilled with UNICEF-provided drilling rigs. Results of this survey and a subsequent one in Maharashtra indicated that at least 75 percent of the handpumps were broken down at any given time. Unless something was done to improve the situation with regard to handpump quality, installation and maintenance, the continued drilling of village wells could no longer be justified.

In 1975, the Government of India (GOI) and WHO organized a handpump workshop in Bangalore with participation from various state Chief Engineers, MERADO (Mechanical Engineering Research & Development Organization) and UNICEF. A WHO consultant, funded by UNICEF, had begun work in 1973 evaluating handpumps throughout the country and had made a number of recommendations with regard to a new design. Although the design proposed was similar to the Jalna pump, it was to be made of cast iron and would have been excessively heavy with no great advantage over its predecessors; the Bangalore pump, as it was known, never went into production. The consultant also worked on the development of a deep-well cylinder to be made of nonmetallic components for a hopefully lower cost than the brass cylinders which were at that time common. These cylinders were laboratory tested by MERADO (a government organization) in Madras but subsequently failed during field testing.

By 1975, UNICEF became more actively involved in handpump development and took the lead in coordinating the activities of the voluntary agencies in Maharashtra, as well as promoting developments based on the Maharashtra experience at MERADO. Several thousand Sholapur-type pumps were produced by the AFARM group in Maharashtra. It was still necessary, however, to convince

GOI that there was an urgent need for an improved handpump and a programme of "rejuvenation" was initiated. This was aimed at removing the working parts of the old cast-iron pumpheads and replacing them with what became known as the Sholapur conversion head: basically, the top part of a Sholapur pump mounted on an existing cast-iron pedestal. The success was such that state government Public Health Engineering Departments (each state government decides and implements its own water supply programme) began receiving requests for the supply of this more durable design; GOI was now convinced of the need for an improved handpump through further development.

THE INDIA MARK II DESIGN

From this moment onwards, UNICEF worked closely with MERADO and Richardson & Cruddas (A Government of India Undertaking), who were both located in Madras. The Sholapur handpump was taken as a starting point for development. It was modified in many ways, primarily to make mass production easier. It was also felt necessary to design the pump in such a way that it could be made in simply equipped workshops. There are, for example, no compound curves on the India Mark II apart from the quadrant which can be easily bent and radiused. A number of design features were introduced to make it easier to maintain and to prevent tampering; and the entire pump was strengthened. The pedestal diameter was increased from five to six inches to accommodate a five-inch casing pipe which was commonly used by 1976.

An important innovation was the use of a solid bar in place of the pipe handle adopted by Sholapur. This counterbalanced the weight of the connecting rod and made it possible for young children to use the pump. Many critical dimensions of the Sholapur pump were retained; however, whereas the Sholapur design was in two parts--head with water tank and pedestal--a decision was taken to introduce a modular three-part design for the Mark II: head, water tank and pedestal which made installation and repair easier. It was also thought that once a pedestal was embedded in concrete, it would remain there for many years, whereas the head design would continue to change. The pedestal could provide a convenient mounting for both a new head design or even a power pump.

The cylinder developed by the WHO consultant was unsuccessful, and it therefore became necessary to identify an alternative as soon as possible so that a complete unit could be simultaneously tested. UNICEF had introduced cast-iron Dempster handpumps and cylinders many years earlier and a Dempster-type cylinder was adopted for the India Mark II. This was a twelve-inch brass-lined cast-iron cylinder which was shorter, cheaper and more durable than the all-brass cylinders common until that time. Twelve preproduction pumps and cylinders were tested for one year in Tamil Nadu from October 1976 to October 1977. All pumps survived the testing under heavy usage with minimal problems or damage. A number of changes were made, however, to strengthen certain weaknesses that had shown up: heavier duty handle stops, flange gussets, and longer handles to provide greater mechanical advantage. The major design features of the India Mark II are summarised below:

MAJOR DESIGN FEATURES OF THE INDIA MARK II

Component	Feature
Head Assembly	<ul style="list-style-type: none">- Sturdy mild steel box containing the handle pivot.- Simple inspection cover secured by a single bolt.- Heavy-duty handle stop permitting rough use without damage.- Flange mounting to water tank.
Handle Assembly	<ul style="list-style-type: none">- Solid bar handle to counterbalance connecting rods.- Sealed ball bearings.- Chain linkage for gravity return of piston.- Quadrant and chain to ensure connecting rod alignment.- Splash washer to help prevent wetting of chain.
Water Tank Assembly	<ul style="list-style-type: none">- Angled spout making ingress of debris to water tank difficult.- Heavy-duty riser pipe holder raised above the spout to prevent ingress of debris to cylinder.- Flange mounting to pedestal.
Pedestal (Stand) Assembly	<ul style="list-style-type: none">- 6-inch ID pipe pedestal fitting over borewell casing pipe.- Angle-iron legs to ensure a firm bond to a concrete base.- Sanitary seal created between OD of well casing and ID of pedestal to prevent infiltration of polluted water to well.- Flange mounting providing for further head development or alternative mounting (e.g., power pump).
Connecting Rods	<ul style="list-style-type: none">- Mild steel bright bar, electrogalvanized for surface protection.- Welded couplings to facilitate maintenance and accelerate installation.- 3-metre lengths for ease of handling.
Rising Main Pipe	<ul style="list-style-type: none">- 32-mm ID medium grade galvanized pipe in 3-metre lengths to facilitate installation and repair using hand tools.
Cylinder Assembly	<ul style="list-style-type: none">- Cast-iron case for low cost and to protect brass liner.- Brass liner with mirror finish to prolong leather bucket washer life.- Quality-controlled chrome-tanned leather buckets.- Rubber seated valve poppets for effective sealing.

PRODUCTION, QUALITY CONTROL & STANDARDISATION

The introduction of an improved handpump design was only the beginning of a long road towards eventual village-based maintenance and continual safe drinking water. The first step was the development of production units in each and every Indian state installing large numbers of handpumps. Since 1977, UNICEF has taken on the role of developing and qualifying new manufacturers of India Mark II handpumps. Through a process of vendor questionnaires to potential new manufacturers, factory inspections, technical assistance and trial orders, UNICEF has helped develop, over the past seven years, thirty-six qualified suppliers of India Mark II handpumps and spare parts throughout the country. However, it was only in 1982 that sufficient production capacity had been developed to meet the current demand of over 100,000 handpumps per year. To date, more than 600,000 India Mark IIs have been installed throughout India.

Simultaneously with production has been UNICEF's continual involvement in the standardisation of the India Mark II design. As soon as the initial prototypes were being field tested, various copies, imitations and substandard versions of the India Mark II design began to appear in the market. Initially, UNICEF distributed the production drawings and specifications. However, the decision was made with the Government of India to give the drawings and specifications to the Indian Standards Institution (ISI) as one means of standardising the design. The first ISI specification appeared in 1979 as IS:9301-1979 (Specification for Deep-Well Handpumps).

Quality control of the production and standardisation has been a cornerstone of the programme since the India Mark II design was first finalised. It was clear from the beginning that in order to develop production units in each state which were to make a handpump of exactly the same design, it would be essential to have stringent internal as well as external quality control. The pumps needed to be made strictly according to the specifications and to a high standard in order to ensure the longest possible life and interchangeability of parts among the pumps produced by the various manufacturers.

UNICEF instituted a system of pre-delivery inspections for all handpumps leaving a factory. It was obvious, however, that the handpumps which the state governments began to buy would also need to be as strictly quality controlled as the pumps which UNICEF procured and provided to the various states for replacement of broken cast iron, Jalna and Sholapur-type handpumps. UNICEF offered to pay for the pre-delivery inspections for state government purchases. Although some of the state governments understood the need for such rigid external inspections, others failed to recognise the necessity. The result was that in the early years (1978-81), many thousands of substandard India Mark II handpumps entered the field. A lot of time and effort was devoted to eventually convincing each and every state government of the need for the strict external, third party pre-delivery inspections.

INSTALLATION AND MAINTENANCE

Even quality, standardised India Mark II handpumps will break down in a short time or provide contaminated drinking water if not properly installed with a platform and drain. UNICEF has been actively involved in training

installation and maintenance personnel and their supervisors and in disseminating manuals and circulars regarding proper installation and maintenance.

Since 1976, UNICEF has been promoting and advocating the adoption of a three-tier maintenance system consisting of village volunteer caretakers, block (smallest administrative unit) mechanics and district mobile maintenance teams. This model was successfully demonstrated on a small scale, but has so far been fully implemented in only a few districts in the country. Although no state has yet built up a complete three-tier or other type of maintenance system, all states have over the past several years allocated more funds and personnel for maintenance of handpumps. Every state has some district and block level personnel dealing with handpump maintenance and the awareness of handpumps at the village level has increased. Today, in spite of inadequate maintenance systems, poor installations and a certain percentage of substandard handpumps, spot surveys continue to confirm that more than 75 percent of the India Mark II handpumps installed are in working order at any given time. This is a dramatic reversal of the situation of just few years ago.

INDIA MARK II DEVELOPMENT CONTINUES

Through ongoing monitoring by UNICEF field staff and feedback from state government personnel, weaknesses and shortcomings in the India Mark II design are discovered, and proposed improvements field tested and then incorporated into the ISI specification. The first revision of IS:9301 appeared in 1982 and incorporated the following improvements:

- water tank gussets - to prevent flange failures.
- thicker front cover - to make more robust and corrosion-resistant
- larger drain opening on head assembly - to evacuate water more easily.
- longer plunger rod - to provide for easier installation.
- hot-dipped galvanizing of all above-ground assemblies - to improve corrosion resistance.

The second revision will be published in late 1984 and will contain the following further improvements:

- stainless steel axle - to avoid rusting and consequent difficult removal.
- solid handle stop gussets - to strengthen the existing stops.
- larger diameter spout - to evacuate water more rapidly and avoid the possibility of wetting the chain and bearings.

- connecting rods with hex couplers at each end - to accelerate installation and ensure tighter joints.
- revised configuration for pedestal legs - to provide better balance in storage and length after installation.

All of the above changes are implemented to make the India Mark II more durable, easier to install, or easier to maintain. Field monitoring also points out areas in the manufacturing process which must be more closely checked during pre-delivery inspections.

One of the key elements to eventual village-based maintenance and the long-term success of the programme will be the development of modified below-ground components for the India Mark II handpump. Field testing is currently under way on the use of plastic rising mains-cum-cylinders to make removal of pump buckets and foot valves easier. The development of lighter weight below-ground components and extractable cylinder components will make it easier to train villagers to maintain and repair their own handpumps.

CONCLUSION

The India Mark II programme was conceived as a system rather than as the development of a mere handpump; special tools to facilitate installation and maintenance and training materials have been developed side-by-side with the pump. The India Mark II itself, unlike many other "new" handpumps, has evolved over a period of some fifteen years to its present position as probably one of the best deep-well reciprocating handpumps in the world--developed in villages, not in laboratories. Its success lies in simplicity of design, quality of production which is carefully controlled by external inspectors, ease of operation and maintenance, and low cost. And why is it called the India Mark II? In recognition of its Indian origin and the many individuals and organizations who contributed so much to the early designs.

UNEP INVOLVEMENT IN
THE RURAL WATER SUPPLY AND SANITATION SECTOR

Leticia E. Obeng
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I have been asked several times what UNEP stands for, and I welcome this opportunity to describe the organization's work, especially as it relates to the purposes of this workshop.

In 1972, when the UN Conference on the Human Environment held in Stockholm identified a number of actions necessary for the preservation of the environment, it was decided to set up a UN Environment Programme to implement the formulated plan of action. Subsequently, the General Assembly established UNEP, with its headquarters in Nairobi, Kenya.

There were two basic but interdependent objectives in the Environment Programme: first, the improvement of the quality of life for all people, especially those in developing countries who, largely through accidents of history, live in conditions under which they are denied the basic human needs of safe water supply, adequate food supply, protective shelter, satisfactory education, good health, etc.; secondly, and also equally important, the protection and preservation of the resources of the environment, i.e., water, soil, plants and wildlife, on which the improvement of the quality of life through development depends.

The inadequate supply of water for domestic use and for food production is in itself a serious environmental problem and therefore of great concern to UNEP. Although not itself an executing agency in the usual meaning of the word, UNEP particularly promotes the safe management of water resources in the course of development in order to ensure their protection and preservation.

From such a standpoint, one has to take a broad view of the problem of water supply and its crucial place within the overall subject of rural development and the environment. Therefore, all options with the potential of solving the problem of inadequate water supply must be seriously considered.

These include the use of water from various sources--surface and groundwaters and atmospheric precipitations (including rain and storm water, dew, and snow)--and the use of alternative forms of water delivery--individual wells, boreholes for community use, communal standpipes, and house connections.

Given the number and complexity of problems faced by rural people in developing countries, this broad view includes an opportunity for contributing to other aspects of development within the context of the improvement of water supply.

There is much room for the application of several options, so varied are conditions in developing countries. However, the options which

provide lasting solutions must be preferred, so that some problems of developing countries may be solved and attention turned to others. Integrated strategies for water supply provide the best approach.

I have personally always firmly believed, judging from world experience on the problem, that the best long-term solution to the inadequacy of water supply is through the installation of piped water, and I believe we must work towards this goal. I have therefore, for many years, held the view that wherever possible and feasible from the conditions existing and the resources available for optimum service and benefit, piped water must be seen as the long-term solution to the problem. Short-term solutions of domestic water supply must equally be as effective as possible. Saying and clinging to such a view in 1975, long before the Water Decade was declared, was like uttering a heresy. At the time, the preferred approach to the improvement of water supply was largely through what was then called "appropriate technology" in the forms of funny gadgets, including some handpumps and windmills, many of which broke down under strain. But these appropriate technologies were religiously pursued, even where piped water would have been the most easily installed method at a reasonable cost.

This view has often been taken out of context and conveniently misinterpreted to mean advocating "sopisticated water supply systems from which only a few will benefit because of high cost". It has also been misinterpreted to be "an anti-handpumps stand". This, of course, goes against my personal experiences in rural water supply and is a ridiculous and quite erroneous interpretation. My long-standing expressed view is for "totally effective and long-lasting water supply" programmes, drawing on all available effective technologies.

Indeed, through the Soil and Water Task Force of UNEP in 1976, a great deal of effort was put into the promotion of rain and storm water harvesting--perhaps the most unsophisticated of water supply systems--at a time when very little thought had been given to the subject for water supply programmes of any organisations. The valuable data which were gathered is now published as useful reference material for areas where rain and storm water can be reasonably used to provide water supply. I truly hope that some development organisation will follow up and implement the findings in suitable regions, e.g., Somalia.

It is a fact that there are areas where groundwater is the only available source for satisfying domestic needs. In these areas, therefore, the current World Bank Handpump Project is essential for solving the water supply problems. Handpump projects are not the only solution to the problem, just as piped water supply and rain water harvesting are not the only solutions. I have been impressed by the dedication and enthusiasm of all involved in the promotion of handpump projects as expressed in this Workshop. The practical approaches to the development of handpumps by our Chinese hosts is especially commendable, and I wish them and the World Bank more grease for the elbows of their illustrious teams.

I do believe, however, from personal experiences in rural life and on the basis of studies of water-related parasites and pathogens responsible for various enteric diseases, that adequate domestic water supply provides opportunities for the improvement of life in rural communities. And I

therefore fully endorse the views expressed by some of our Chinese colleagues that where feasible, groundwater for domestic use should be piped to homes.

I am not an engineer, and my interest in the subject of handpumps will also refer to related aspects of water supply. Therefore, let me emphasize the following points to which thought should be given in preparation for the time when handpumps will be operating widely.

1. I believe that we must, as a matter of urgency, start looking into groundwater recharge rates and patterns, i.e., what, for instance, will be the effect of so much tapping of groundwater on surface waters, especially in periods of drought.
2. We must also, I believe, devise an effective way of checking the contamination of groundwater. Even deep water can be contaminated from natural sources, and we must not ignore this point.
3. I also think that we must give some thought to the design and maintenance of the immediate vicinity of handpumps and the drainage of wastewater.

I mentioned that from an environmental point of view, an integrated strategy is needed for improving water supply to extract maximum benefits for overall development from the projects. One such benefit is in the area of health--and especially the control of some water-related diseases.

A number of water-related and enteric diseases can be avoided by keeping away from the water source of infection. Piping water, which also assures an adequate quantity of water for domestic use, is an effective way of keeping away from transmission sites. Other forms of supply, including handpumps when conveniently situated, are equally effective in providing an adequate domestic water supply, as well as keeping people away from infected water sources.

In 1975, I had the privilege of studying the control and management of schistosomiasis in China; improved domestic supply played a major role in this area.

It is generally believed that piped water installations in rural areas are prohibitive in cost; however, a study of the available information will show that most costs cited in the literature are estimates, often based on urban water supply costs. I suggest, therefore, that it would be useful to obtain costs of actual field installations in order to evaluate the merits of rural piped water supply systems.

In 1976, to further promote integrated rural water supply, UNEP set out to try, through an executing agency, various types of water supply installations in an integrated programme, allowing us to cost various types of water delivery systems under specific conditions. At that time, the mere mention of piped rural water supply to the international community was taboo. The executing agency and others tried their utmost to discredit the integrated water supply programme. The project was completed, however, and the information obtained on the use of wells, boreholes and springs as water sources and the installation of communal standpipes and house connections is valuable. At least, the costs obtained are based on concrete projects and not estimates. The results illustrated that, for the conditions under which the

installations were made and for the long-term and wider benefits achieved, the piped systems are not excessively costly.

The above-mentioned integrated rural water supply programme also had other major components:

- A joint activity on health education, especially in relation to enteric infections;
- The control of water-related diseases, e.g., as schistosomiasis, and the protection of surface waters;
- Promotion of full participation by the people so that all might benefit from the programme. Ideally, rural water supply is expected to be a government responsibility. Water is so necessary to life that it should be a social right. Governments, however, have too many responsibilities on their hands and the people must, under present circumstances, help themselves. The success of rural piped water programmes depends on the full support of the people.

From our experiences, we have learned that if people really want a facility, they will work for it; and it is not difficult to find out if they want it. The question has been asked as to how one gets the people to participate in such programmes. I will share with you my recent experiences from the Regional Office for Africa.

From my experiences in the Region until now, I can say with confidence that, for normal communities, participation in productive activities can be obtained with reasonable ease if the intelligence and concern of the people are respected. We have adopted a simple approach--just talking to the people. We do not only talk to the Chief or District Commissioner or community leaders, but to the women, children, farmers and all who have been directly involved with the creation of the particular problem. And, we do not tell them what to do--we tell them the problem and we let them tell us what they think should be done.

In the Regional Office, we adopt this approach as a necessary prelude to national programmes. We work through our Environment National Focal Points, also nationals of the 50 countries of Africa. We call the process "National Consultations". The \$500 which we invest in each National Consultation is repaid several-fold by the ideas and views expressed, and the feeling of responsibility and interest generated among the people towards self-help and self-reliant programmes.

It is difficult to change people, but they will change if they wish. We can try "National Consultations" when we are ready to install handpumps as national programmes and give the pumps a fair chance by assuring care and maintenance by the people. It would be wonderful to involve the people fully with the handpumps programme.

Now, while still on the subject of integrated strategy for water supply, I would like to add a few more points, which may seem controversial, on the relationship between water and health.

Effective water supply is necessary for controlling certain water-related diseases. Even the life cycles of the parasites and pathogens confirm this fact. For example, stop people from drinking water in which the guinea worm develops through infection of the water cyclops, and there will be no guinea worm infections of the people. Install convenient domestic water supply and keep people away from schistosomiasis transmission sites, and transmission will be interrupted. Provide adequate quantities of water in or near the homes, so that it is available for personal and home hygiene, and provide safe human waste disposal coupled with effective health education, and many of the sources for the enteric diseases which kill millions of children under the age of five will disappear.

These are facts which have been proven throughout history, even in the most sophisticated of industrialised countries. For many rural areas, the problem of water supply is not so much one of poor quality, but one in which there is never enough water available in the home for personal hygiene and domestic use. The majority of pathogens responsible for diarrhoeal diseases are ingested as bits of feces under the nails and on the hands of children who play on the ground, either because there is not enough water at home to wash hands or no one has bothered to explain the pathogen infection routes to the children and their parents. Adequate water supply at home is essential; whether it is piped or provided through effective and reliable handpumps is immaterial.

Finally, I would like to assure The World Bank Handpumps Project team that their efforts are also essential for providing alternative sources of water for farming in suitable regions, in order to protect catchment areas and rehabilitate degraded river banks currently causing severe river siltation in some regions.

Compared to man's trips to the moon and test-tube babies, the problems of water supply for the millions of people in developing countries could almost be a joke; yet, on its solution depends the quality of life for millions of people. With the opportunity in our hands to do something, let us be realistic and involve the people we want to help. It would be such a rewarding victory! What we have seen in China should give us the needed inspiration.

ACTIVITIES OF THE WORLD BANK
RURAL WATER SUPPLY HANDPUMPS PROJECT

Saul Arlosoroff, Project Manager, Washington, D.C.
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The World Bank

Point sources for providing water to rural areas, such as wells with handpumps, have proven to be the only viable option for the majority of rural inhabitants in many countries. The costs for these water supplies, both capital and recurrent, are considerably lower than those of conventional systems, at least in the absence of high population density and high per capita water consumption. Moreover, institutional difficulties of operating and maintaining motor-driven piped water supplies in rural areas have caused many of these schemes to become inoperative. It has been demonstrated that wells equipped with handpumps can be viable systems in these same areas if community participation--from the inception to maintenance--forms an integral part of the project.

The Handpumps Project is carrying out both laboratory and field tests, with China being the first developing country to conduct laboratory tests similar to those of the Consumers' Association Testing & Research Laboratory (CATR). Field trials are taking place in Bangladesh, Burkina, Bolivia, China, Ghana, India, Ivory Coast, Kenya, Malawi, Niger, Papua New Guinea, the Philippines, Sri Lanka, the Sudan, Tanzania and Thailand; field trials in Lesotho have earlier been concluded. Major donor countries for these activities are Canada, Denmark, the Federal Republic of Germany, Finland, France, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States; UNICEF is also a major participant in the Project activities.

Efforts are being directed towards the development of Village-Level Operation and Maintenance (VLOM) handpumps, which can serve 250-300 persons for 8-10 hours a day and can be manufactured and maintained in developing countries. Efforts are also being made to create an understanding of handpumps as a reliable water source and to ascertain the incentive systems, appropriate legislation, and donor coordination needed for the large-scale implementation of handpumps throughout the developing world.

SECTION 6

CONCLUSION

CLOSING ADDRESS

Zhou Zheng
Vice Governor
Hunan Province
Changsha, China

The seven-day Ministry of Machine Building Industry, United Nations Development Programme, and World Bank Workshop on the Handpumps and Their Application to Water Supply and Sanitation has satisfactorily obtained the expected objectives of the participants.

During the meeting, the participants of different countries exchanged experiences in the research, manufacture, testing, application, promotion and maintenance of handpumps and the benefits of technical cooperation. Topics addressed involved the development of handpumps and rural water supply and sanitation. During the meeting, lecturers and participants visited the Hunan Provincial Research Institute of Agro-Machinery and its handpumps laboratory and field testing sites in Wang Cheng County. The participants' opinions on the testing of handpumps will surely benefit future work in China and promote the improvement of the rural water supply and sanitation of the province, nation and whole world.

I believe that the workshop will further promote the activities of the programme of the International Drinking Water Supply and Sanitation Decade. We are willing to continue our effective cooperation with foreign countries and world organizations and make our contribution towards the realization of the UN global objective under which all people enjoy safe water and adequate sanitation by 1990. Meanwhile, we look forward to undertaking economic and technical exchange and cooperation with foreign countries and international organizations in other fields.

In addition, participants have learned of advances in drilling equipment and development of energy and water conservancy in the rural areas of the province, following visits to the Changsha Drilling Equipment Factory, the methane utilization in Xiangtan suburbs, the Shaoshan Irrigation Project and the Birthplace of the late Chairman Mao.

The Provincial Government of Hunan eagerly hopes the participants of the workshop come to Hunan in the future.

ANNEX A

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ANNEX B

PROGRAM FOR WORKSHOP PRESENTATION
AUGUST 13 TO 21, 1984

Monday	August 13	Afternoon	Welcome Meeting
		6:00 - 6:10	He Guangyuan, Vice Minister, MMBI
		6:10 - 6:20	A.W. Sissingh, Senior Adviser, UNIDO
		6:20 - 6:30	W. Nolle, Deputy Chief of Mission, Embassy of the Federal Republic of Germany
		6:30 - 6:40	M. Cohen, Division Chief, WUDSR, World Bank
Wednesday	August 15	Morning	Opening Presentations
Chairman:		9:00 - 9:20	He Guangyuan, Vice Minister, MMBI
Sissingh		9:20 - 9:40	Zhou Zheng, Vice Governor of the Hunan Province
		9:40 - 10:00	S. Arlosoroff, Unit Chief, WUDAT, World Bank
		10:00 - 10:20	W. Knipschild, Senior Counsellor, BMZ, FRG
		Afternoon	
Chairman:		2:00 - 2:40	Li Jiuru, Central Patriotic Health Campaign Committee
Arlosoroff		2:40 - 3:20	Feng Bingyuan, CAAMS
		3:20 - 3:40	M. Beyer, UNICEF
		3:40 - 4:00	G. Tschannerl, World Bank
		4:00 - 4:20	Tea Break
		4:40 - 5:00	L. Rosenhall, World Bank, Bangkok
		5:00 - 5:20	O. Langenegger, World Bank, Abidjan
		5:20 - 5:40	D. Grey, World Bank, Nairobi
		5:40 - 6:00	K. Mills, CATR
Thursday	August 16	Morning	Laboratory and factory visit
		8:00 - 10:00	Hunan Institute of Agricultural Machinery
		10:00 - 11:30	Drilling equipment factory
		Afternoon	
		2:00 - 6:00	Wangcheng Commune
Friday	August 17	Morning	Presentations by country staff and bilateral agency representatives
Chairman:		8:00 - 8:20	L.J. McDonald, CIDA
Feng Bingyuan		8:20 - 8:40	M.B. Grieveson, ODA
		8:40 - 9:00	H. Eylers, GTZ
		9:00 - 9:20	A. Djouka, Ivory Coast
		9:20 - 9:40	H.V. Krishnaswamy, India
		9:40 - 10:00	F. Padernal, Philippines

Friday August 17 Morning (cont.)

10:00 - 10:20 Tea Break
10:20 - 10:40 D.M. Kirori, Kenya
10:40 - 11:00 A. Hartmann, SDC
11:00 - 11:20 Chetpan Karnkaew, Thailand

Afternoon

Chairman: 2:00 - 6:00 Discussion
Sissingh

Saturday August 18 Morning

Chairman:
Rosenhall

Research and development, state of the art, continuing country staff and bilateral agency presentations

8:00 - 8:20 L. Obeng, UNEP
8:20 - 8:40 R. Winberg, SIDA
8:40 - 9:00 R. Diaz-Diaz, UNICEF Sri Lanka
9:00 - 9:20 K. Gray, UNICEF India
9:20 - 9:40 K. Homanen, Finnwater
9:40 - 10:00 G.J. Bom, Netherlands Aid
10:00 - 10:20 Tea Break
10:20 - 10:40 K.B. Boyagoda, Sri Lanka
10:40 - 11:00 D.S. Sharp, IDRC
11:00 - 12:00 Discussion

Afternoon

Chairman: 2:00 - 4:00 Discussion
Feng Bingyuan 4:00 - 6:00 Cultural Visit

Sunday August 19

Cultural Visit

Monday August 20 Morning

Chairman:
Arlosoroff

Presentations and discussions on the application of handpumps for small-plot irrigation, nutrients application and urban-fringe water supply--
Arlosoroff, World Bank

Afternoon

Chairman: Discussion
Feng Bingyuan

Tuesday August 21 Morning

Chairman:
Feng Bingyuan

Concluding sessions

8:00 - 8:10 Zhou Zheng, Vice Governor, Hunan Province
8:10 - 8:20 W. Knipschild, BMZ, FRG
8:20 - 8:30 M.A. Cohen, World Bank

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