HOME

Water Supply and Sanitation

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After sufficient food, a good clean water supply and adequate sanitation system are considered to be the most important factors in ensuring good health in a community. Improved water supply and sanitation systems were major elements of the public health measures that drastically cut death rates and improved health levels in the industrialized countries. Though it is not generally appreciated, these measures have been considerably more important than curative medicine in contributing to good health, long life expectancy and low infant mortality. Infant diarrhea, the largest killer in developing countries, is closely related to poor water quality.

The first books in this section provide a context for discussion of water supplies the social and ecological effects of water systems (including large dams and irrigation projects in addition to community water supplies), and the nature of water supply needs, constraints, and possibilities for communities in the South.

Due to their great potential benefits, village water supply systems have been favorite development projects of government and international agencies for several decades. They make a revealing topic of study for appropriate technology advocates, as they represent one task for which small-scale technology has been widely promoted. A basic conclusion: a water supply or sanitation project that is imposed on a community, without community involvement in determining the need for and nature of the system, or without an effort to train some community members to do maintenance and repair, is very likely to fail.

Participation and Education in Community Water Supply and Sanitation Programmes: A Literature Review offers valuable insights into the requirements for successful programs that fully involve the community. With 20-50% of handpumps in rural areas of the South broken down at any one time, the appropriate technology solutions seem to depend on local people and institutional arrangements that can ensure good maintenance and rapid repair. This also implies the use of equipment that can be repaired at the local level.

More than 20 of the entries in this section are manuals on the various aspects of the planning and installation of small water supply systems, including wells, pipelines, storage tanks, and drainage. Another thirteen publications on pumps and water lifters range from broad inventories of water lifting devices to construction plans for particular pumps. **Laboratory Testing of Handpumps for Developing Countries** presents the results of extensive testing of 18 widely-used handpumps. Four additional entries describe the construction and use of ferrocement and bamboo-reinforced tanks (sometimes used in roof rainwater catchment). These are followed by seven publications on water filtration and treatment. In sand filtration, water is passed

slowly through a tank filled with sand. The sand traps large particles, and it holds the bacteria that digest fecal matter naturally so that it will be harmless to humans. Solar distillation is another option for water treatment; this is covered by five entries.

The bibliography **Low Cost Technology Options for Sanitation: A State of the Art Review** offers an excellent summary of the sanitation technologies relevant to urban and rural settings in developing countries and is a guide to the technical literature (mostly hard-to-get research reports). **Small Excreta Disposal** is a valuable small reference manual on the range of waste disposal alternatives that can be used in small communities. The next books describe dry composting toilets and ventilated pit latrines as alternatives to expensive water-borne sewage systems. Many variations have been tried in many different countries; some have been built by the tens of thousands. Most of these books are primarily relevant to conditions in the South, while **Compost Toilets: A Guide for Owner-Builders** and several others were written for North American audiences. Natural treatment of water-borne sewage in a marsh pond is a relatively low-technology approach that seems to have potential for some communities in North America. **Natural Sewage Recycling Systems** describes work done on this technique in the United States. This type of system is now being used by the city of San Diego in southern California. A similar system using fish ponds in cities of China and India is described in **Aquaculture: A Component of Low Cost Sanitation Technology**.

With several drought years and greater demands on existing water supplies in the western United States, there has been much recent interest in the reuse of household wash water in gardens and yards. **Residential Water Re-Use** is an excellent compendium of technology ideas and the basic technical considerations of such greywater systems. The last entry in this section, **Management of Solid Wastes in Developing Countries**, discusses refuse collection and transport, sanitary landfills, and composting of urban wastes.

In This Section

A. Water Supply: General Considerations

The Social and Ecological Effects of Water Development in Developing Countries, book, 127 pages, edited by Carl Widstrand, 1978, out of print, microform edition available from O.P. Books Department, Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523, USA.

"During recent years it has been shown quite clearly that the expected social benefits from drinking water supplies have not been realized and that irrigation projects have created more problems than they solve. None has fulfilled the expectations of planners and government and most projects are used only to 50% of their capacity. This means that 100 million ha. of land with available irrigation are not used and that millions of rural people who are provided with pumps, pipes and installations cannot get any water out of them. This book is concerned with why this has happened and what can be done about it." These articles are by 10 people experienced in water systems work in the South.

Most irrigation schemes "appear to create subsidized income elites; contribute to food production only at high cost; facilitate preconditions for inappropriate mechanization and thus a disappointing employment creation record; and they lead to various aspects of environmental degradation. Public health considerations are typically ignored."

Much of the poor performance of water development schemes is attributed by two of the authors to structural problems in the way research and planning are conducted. David Henry notes that a poor learning situation for planners has prevented them from learning from the mistakes of the past two decades. Robert Chambers points to the problem of research priorities that are determined more by the need for recognition among professional colleagues than by the real needs of rural people: "... the

primary criterion for good research should be that it is likely to mitigate poverty and hardship among rural people, especially the poorer rural people, and to enhance the quality of their lives in ways which they will welcome; that in short, priorities should be ... grounded in the reality of the rural situation. Starting with rural people, their world view, their problems and their opportunities, will give a different perspective. To be able to capture that perspective requires a revolution in professional values and in working styles; it requires humility and a readiness to innovate which may not come easily in many research establishments."

Some of the lessons for planners and donors: "more funds and more resources into public health training and education (with local teachers), more funds into training programs for operators and maintenance personnel not producing full-scale engineers, but, instead, small-scale mechanics with some basic skills directly applicable to the water system and more thought about the involvement of locals in the planning of water schemes."

Highly recommended.

Environmentally Sound Small-Scale Water Projects: Guidelines for Planning, Disk 12, File 10-320, book, 142 pages, by Gus Tillman, 1981, $12.95 from VITA; also available in Spanish; also available from TOOL.

"This booklet has been written for community development workers in developing countries who are not technicians in the area of water resources. It is meant to serve as a general guide when planning environmentally sound small-.scale water projects that is, projects which protect and conserve natural resources in a manner which allows sustainable development to take place." Material covered includes a general introduction to ecological principles, the water cycle in the environment, disease control and sanitation, water resources development, and project planning. It is intended that more specific manuals will be consulted for technical details when needed. Recommended as an introduction.

Drawers of Water, book, 306 pages, by Gilbert White, David Bradley, and Anne White, 1972, $25.00 from University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois 60637-1496, USA.

Combining engineering, economics, health and sociology, **Drawers of Water** is "a broad view of domestic water supply in the developing tropics." Using examples and studies from East Africa, the authors discuss: traditional water supplies and use in urban and rural communities; the range of attempted and possible improvements; the health costs and benefits of improved water systems; individual and social "costs"; and the successes and problems of standard economic and technical planning methods.

Drawers of Water is intended for "decision-makers" in developing countries much of the book contains technical discussions of data from sociological and economic studies. The book's strength, however, is that it recognizes that "accepted" planning methods must be altered to account for local physical and social conditions.

Guidelines on Health Aspects of Plumbing, **Disk 12, File 10-322**, book, 168 pages, by Floyd Taylor and William Wood, 1982, $16.50 from IRC; also available in Spanish.

Water and sewage systems installed by public authorities must interact with privately constructed systems at individual buildings. Bad design or faulty installation of the private systems can result in pollution (e.g., through back-siphoning), damage or overload to the public systems, with accompanying health risks to the rest of the community and higher costs to the system. This book attempts to lay out a basic plumbing code of practice to minimize these risks, to be enforced by local authorities.

The problem is a real one, primarily occurring in urban systems. The difficulty of coming up with a generalized code of practice and a set of controls is that it necessarily requires certain assumptions about risk and cost tradeoffs that certainly vary from one place to another. Who is to say that the ad hoc water systems that dot slum communities, certainly in violation of any code of practice, are creating more risks than benefits? In particular, experience has shown that

building codes in developing countries tend to set standards that are not affordable for the poor majority, and that ignore the piecemeal, self-help, make-do-with-the-materials-at-hand approaches these people are forced to use. This book is an interesting attempt to deal with a thorny problem.

Water for the Thousand Millions, **Disk 12, File 10-321,** book, 58 pages, edited by Arnold Pacey, written by the Water Panel of ITDG, 1977, out of print in 1985.

This short volume differs from the other general water supply books in that it is explicitly about "appropriate water supplies", including the consideration of economic, social, environmental and health factors in determining. "appropriateness." The authors have concentrated on how these factors are combined in a variety of low-cost water systems that could be used by the thousand million people currently without clean drinking water.

"Water supplies are not an all-or-nothing phenomenon. Almost every situation lends itself to some improvement, even if funds and skills are severely limited." The key is matching people's needs and cultural patterns with the given water supply potential and much broader technical choice than is usually offered by governments or development agencies.

B. Participation: A Key to Successful Systems

Participation and Education in Community Water Supply and Sanitation Programmes: A Literature Review, Technical Paper No. 12, **Disk 12, File 11-323**, book, 204 pages, by Christine Van Wijk-Sijbesma, 1981, $34.00 from IRC; also in Spanish.

An extraordinary review of conclusions from a wide literature on the participation of communities in water supply and sanitation programs, this should be required reading for people working in these fields. For more information on specific concepts, the reader can refer to the original studies. This volume offers planners and community organizers the opportunity to avoid many of the common mistakes of the past and create programs with a maximum of community participation. It is also a good general guide for involving the community in any kind of appropriate technology activity, stressing their own perceptions of problems and solutions. An annotated bibliography, published as No. 13 in the Technical Papers Series, contains detailed abstracts of the 145 most relevant works on which the literature review is based.

Community participation in decision-making and implementation brings a number of rewards. It is a more democratic approach than imposition of projects from outside. It provides good opportunities for the growth of skills and competence at the grass-roots level increasingly recognized as the most central goal of development. And it is more likely to be successful in solving problems.

Some of the authors have noted that hand pumps are broken down 20 to 70 percent of the time and that in some countries, village water systems are breaking down faster than they are being built. "A community is more likely to cooperate in the implementation, operation and maintenance of new systems if it has had a say in the preparation of plans."

In some countries, water supply programs have been divided into three categories. In communities where water supply and sanitation problems are felt by the entire population, the government agency offers assistance with forming a local committee and planning a work program. If problems are felt only by the village leadership, these people are supported with media and locally-planned primary school education programs to generate broader motivation to solve the problems. If problems are felt only by the water supply specialist, "various surveys are carried out with the involvement of the villagers, a motivation and education campaign is set up, and assistance is provided in solving other, more deeply felt village problems."

Many observers have "stressed the importance of presenting the community with the various technological solutions which are feasible, ranging from simple source protection and pit latrines to multiple house connections ... Community choice should include the possibility of rejection of any immediate source improvement ... Although this may seem a negative outcome ... each community has its own criteria for calculating sets of trade-offs, so that their perceptions of the usefulness and effects of improvements may differ considerably from those of the agency. Besides, self-made choices will ensure a greater commitment than solutions presented from outside."

Recently, some authors have emphasized the need for participatory research, "because it is a process which is part of the total educational experience, serving to identify community needs and to effect increased awareness and commitment." Two of the more innovative information-gathering and educational approaches briefly discussed are the "environmental sanitation walk" with a group of villagers, and the "community self-survey."

Highly recommended.

Hand Pump Maintenance in the Context of Community Well Projects, **Disk 12, File 11 -322**, booklet, 43 pages, by Arnold Pacey, 1977, revised 1980, £4.50 from ITDG.

This booklet is part of an Oxfam series on socially appropriate technology. The author looks at community well projects in developing countries and examines why over 60% of these break down and/or are not used. The reason for this is not due to faulty design of the pumps themselves, but because "... the community or village has not been adequately involved in the project in the first place, and has not accepted the social responsibility for the task of maintaining the pump."

"An effective pump system is not simply a technological object but a conglomerate of technology, institutions and people." With this in mind, three approaches are possible: 1) total village self-reliance, where a pump is manufactured using only those materials and skills available locally, 2) partial self-reliance, where a pump may be made outside the village, but the responsibility for maintenance lies within the village, and 3) elimination of village responsibility, usually by use of a manufactured imported pump which requires no maintenance (the most expensive option).

The conclusion is that the partial self-reliance path is most applicable in a variety of situations. Locally-made pumps will also work for low-lift applications. This booklet is most valuable as a reminder that local people and their institutions are at least as important as the hardware in the introduction of any community-level technology.

Recommended.

C. References

Using Water Resources, **Disk 12, File 12-327**, book, 143 pages, VITA, 1970 (reprinted 1977), $8.25 in U.S., $8.75 international surface mail, $11.75 international air mail, from VITA.

Due to the international demand for information on water supplies, VITA has reprinted this from its **Village Technology Handbook** (see review). Subjects are:

a) Developing water resources: basic well-drilling and digging information, including how to make various hand drilling tools ;

b) Water lifting and transport: measuring water flows, bamboo piping systems, chain pump and inertia pump for irrigation, hydraulic ram pump ;.c) Water storage and water power: springs, cisterns (tanks), dams, power transmission;

d) Water purification: boiler for drinking water, chlorination methods, sand filter.

D. Small Water Supply Systems

Rainwater Harvesting: The Collection of Rainfall and Runoff in Rural Areas, **Disk 12, File 12-328,** book, 220 pages, by Arnold Pacey with Adrian Cullis, 1986, £9.95 from ITDG.

This is an exploration of rainwater catchment tanks for drinking water and traditional methods of runoff farming in which rainwater is channeled to planted areas. In poor countries, rainwater catchment tanks are usually built smaller than optimum technical size because of cost considerations. In addition, it is quite common for users to rapidly consume collected water, leaving a subsequent dry period when no water is available. Runoff farming has been successful in the Negev desert in Israel (in winter), in the southwestern United States, and in other countries (notably India, which may offer the most relevant experience for other tropical areas). One key to identifying successful conditions for runoff farming is the balance between rainfall and evaporation during the growing season, and the distribution of storms. Areas with occasional heavy rainfall but hot growing seasons may be less suited for runoff farming than areas with less heavy but more consistent rainfall and lower temperatures.

Manual for Rural Water Supply, **Disk 12, File 13-333**, book, 175 pages plus foldout drawings, Helvetas, 1980,1985 fifth edition Swiss Francs 34.00 from SKAT; also available in Spanish and French; also available from VITA and TOOL.

A very thorough book on small community water supply systems based on 15 years experience of the Swiss Association for Technical Assistance and the Community Development Dept. in Cameroon. The basic elements of a distribution system are presented wells, springs, stream diversions, storage tanks, distribution pipelines and stand pipes. There is a brief maintenance checklist.

This book is unusually broad in scope, beginning with the yearly water cycle (rain to groundwater) and then discussing standards for water quality that are realistic and affordable in rural Cameroon. Also unusual: coverage of the corrosive effects of water flowing through a variety of piping materials, and what can be done about this. Emphasizes the planning of distribution systems for expansion with expected population growth.

Widely relevant.

Water Supply for Rural Areas and Small Communities, WHO Monograph #42, **Disk 12, File 13-346**, book, 327 pages, by E. Wagner and J. Lanoix, 1959, out of print in 1985.

This important reference work on water supply deals with both supply systems and sanitation considerations. It focuses on the development of a water supply program, including installation, operation, maintenance, and management.of water supply programs. Besides thorough coverage of rural sanitation, a significant part of the book is devoted to guidelines for effective management of water supply systems after their installation, and efforts to create and sustain community awareness and participation. Most importantly, an entire small community's water supply can be thoroughly planned with the use of this book taking into consideration all major aspects such as geological formations, topography, needs analyses, flow, distribution, storage systems, and the vital human component what happens when people accustomed to crossing ravines and climbing down steep slopes have potable water flowing from a tap.

Small Water Supplies, Ross Bulletin No. 10, booklet, 54 pages, by R. Feachem and A.M. Cairncross,1986 £3.50 from Ross Institute, London School of Hygiene and Tropical Medicine, Keepel (Gower) Street, London WC1E 7HT, England; or ITDG.

This handbook is for "someone who wishes to build only a few water supplies (systems) using simple equipment easily available to him; typically a rural health worker." It is not intended for those working with large-scale water supply systems. All aspects of designing a water supply system are presented for the novice. The subjects include preliminary design, water sources (wells and boreholes), raising water (how to choose pumps of all types), water treatment, storage (dams and tanks), pipes, and distribution. There is an extra chapter on purification on an individual scale.

An appendix describes bacterial analysis of water using simple equipment and MacConkey broth (available from Oxoid Ltd., Wade Road, Basingstoke, Hampshire, England; or Difco Laboratories, Detroit, Michigan 48201, USA.)

This book covers material similar to that in **Water Supply for Rural Areas** by WHO (see review). **Small Water Supplies** is significantly less expensive, and while less detailed it does include a wide range of material on water purification and general aspects of small water systems. For these reasons, we highly recommend it.

Small Community Water Supplies, Technical Paper No. 18, **Disk 12, File 13-344**, book, 415 pages, 1983, $37.00 from IRC; also in French and Spanish; also from TOOL.

Covers technology of small community water supply systems including planning and management, water quantity and quality, water sources, rainwater harvesting, springwater tapping, groundwater withdrawal, surface water intake, artificial recharge, pumping, water treatment, aeration, coagulation and flocculation, sedimentation, slow sand filtration, rapid filtration, disinfection, water transmission, and water distribution.

Rural Water Supply in Developing Countries, **Disk 12, File 13-337**, book, 144 pages, 1981, IDRC, publication IDRC-167e, out of print.

This collection of papers presented at a regional workshop on water supply held in Malawi provides a profile of low-cost water supply options for rural Africa. It includes a wide selection of designs and technologies while emphasizing local participation, planning, and training to upgrade water supply in the difficult circumstances found in this region. Recommended.

Rural Water Supply in Nepal: Technical Training Manuals 1-5, 5 short booklets, 1978, by the Local Development Department of Nepal, UNICEF-Nepal, out of print.

These five manuals are very simple training materials for those working in rural water supply development in Nepal. They range from 13 to 30 pages in length and give brief introductions in the following areas:

1) **Hydrology and Water Cycle** (**Disk 12, File 13-340**) the climatology and general water availability in Nepal.

2) **Stone Masonry** (**Disk 12, File 13-342**) how to build tanks and basins for water storage, using stones and cement.

3) **Concrete** (**Disk 12, File 13-338**) mixing and using concrete; also for water storage.

4) **Pipes and Fittings** (**Disk 12, File 13-341**) an introduction to pipes and fittings commonly used in Nepal; both galvanized iron and HDP (high-density polyethylene). This manual is useful in showing welding techniques for joining pipes. The advantages and disadvantages of each material are presented: iron is heavier but stronger and easily available; HDP is an easily damaged synthetic that is cheaper, easily connected, and doesn't require special joints.

5) **Construction Design Course** (**Disk 12, File 13-339**) source protection, water treatment, storage tanks, pressure-reducing unit pipelines, and public water tanks.

These manuals are useful examples of how simple but necessary skills for a set of local conditions can be communicated.

Rural Water Supply in China, **Disk 12, File 13-336,** book, 92 pages, 1981, IDRC, publication IDRC-TS25e, out of print.

Water supply solutions for the range of conditions found in the People's Republic of China are presented in a thorough and informative manner. The pragmatic text and clear drawings should allow any of the techniques to be replicated in a rural situation at reasonable cost. Includes information on well location, drilling, casing, and repair. Also covers water lifting, filtering, treatment, storage, distribution, etc. Very useful. Highly recommended.

Rainwater Harvesting for Domestic Water Supply in Developing Countries: A Literature Survey, **Disk 12, File 13-335**, order no. WASH C-252, paper, 103 pages, by Kent Keller, free to developing countries from the U.S. Agency for International Development, Water and Sanitation for Health Project, 1611 North Kent Street, Room 1002, Arlington, Virginia 22209, USA.

Rainwater harvesting systems offer many advantages for water collection. Systems can often be adapted to fit locally available skills, materials, patterns of rainfall, and water consumption. Costs of catchment systems are often low relative to

other alternatives, and catchment systems can be installed incrementally, reducing high initial costs. Discussion focusing on systems for family and small-scale community water supply are presented in three main sections: "Broad

Concerns and Basic Constraints in Rainwater Catchment," "Catchment Technologies" and "Storage Technologies of 'Tanks'." Each section finishes with a list of published references and ordering information (a number of the referenced materials are included in this microfiche library). Finally, brief technical notes are presented for planning and construction of a few promising rooftop catchment designs. Lucid and comprehensive.

Village Water Systems, **Disk 12, File 13-345**, book, 100 pages, by Carl Johnson, UNICEF, Nepal, out of print in 1985.

This is written as a reference for designing water distribution systems, with an emphasis on conditions found in the mountain regions of Nepal.

"Design criteria are presented where standard designs cannot be practically used, while the standard designs that are included are for guide purposes only ...."

With charts and sample calculations, the author covers initial surveys, intake works, pipeline sizing, break pressure and reservoir tanks, and public taps. Water quality and/or treatment, windmills and hydraulic rams are mentioned briefly, and the reader is referred to other publications in the bibliography (the book assumes you have access to the UNICEF or WHO libraries in Nepal). An appendix presents a sample design, with calculations, for a rural water supply system and the cable suspension of a flexible pipe (a frequent need in mountainous areas).

A Handbook of Gravity-Flow Water Systems for Small Communities, **Disk 12, File 13-332,** book, 242 pages, by Thomas D. Jordan, Jr., UNICEF/Nepal, 1984, £6.95 from ITDG; also available from TOOL.

This book replaces **Village Water Systems**. Like its predecessor, it is written as a reference for designing water distribution systems, with an emphasis on the conditions found in the mountain regions of Nepal. Topics covered include village evaluation and feasibility studies, topographic surveying, design period, population and water demands, hydraulic theory, air-blocks and washouts, pipeline design, system design and estimates, piping construction, intake works, sedimentation tanks, break-pressure tanks, reservoir tanks, public tap stands, valve boxes, water quality, hydraulic rams, concrete, cement, and masonry.

Recommended.

Design Problems for a Simple Rural Supply System, **Disk 12, File 13-328**, 37 pages, and **Gravity Flow Water Systems**, Disk 12, File 13-330, 48 pages, by A. Scott Faiia, out of print in 1985.

The author wrote these manuals in response to the great number of gravity-fed water systems which he found not working. They do not attempt to be comprehensive in coverage and are still in draft form. Nonetheless, they are useful in that they clarify some basic proven design approaches. "The theory of water system design is extensively covered in other publications. The emphasis here is placed on practical methods that have been tested in the field and have given acceptable results .... The notes are based on several years' experience in Indonesia and have been used for training of field staff responsible for site selection, design, and implementation." **Design Problems** is a workbook with problems based upon the material presented in **Gravity Flow Water Systems**.

Public Standpost Water Supplies, Technical Paper #13, **Disk 12, File 13-349,** book, 104 pages, IRC, November 1979; and **Public Standpost Water Supplies: A Design Manual**, Technical Paper #14, **Disk 12, File 13-350**, book, 91 pages, IRC, December 1979; both out of print.

Most village and town water supply systems in developing countries include public standposts to allow many different users to draw water from each tap. The proper design of such standposts is therefore quite important to the overall success of the water system. These two volumes review the general considerations and design details that should be incorporated into well-planned public taps.

Manual for Water Systems and Pipe Work, **Disk 12, File 13-334**, 37 pages, by Andreas Bachmann and Nir Man Joshi, 1977, available in photocopy form only from SDC or SKAT.

Subtitled "A Brief Introductory Course for the Establishment of Rural Water Supplies in Nepal," this engineering manual is for those involved in design, construction and plumbing of water supplies in rural areas. The concepts are presented with dimensional drawings and simple English explanations.

The first section provides introductory design information for natural gravity and hydraulic ram distribution systems and water conduits (pipes and valves). The rest of the manual covers the use of the three types of pipe available in Nepal:

galvanized iron, HDP (high-density polyethylene) and PVC (polyvinylchloride). Included is information on laying pipe and making many different kinds of joints.

Excellent as a field training manual; some of the information is contained in **Rural Water Supply in Nepal: Technical Draining**, Manual #4 (see review).

Highly recommended.

Residential and Non-Residential Drinking Water Installations and Drainage Requirements in Buildings in Nepal, **Disk 12, File 13-329**, book, 180 pages, revised 1988, by A. Bachmann, from SKAT; photocopies free to serious groups from SDC.

This is an engineering handbook for designing water installations in Nepalese buildings (assuming a low-pressure supply of piped water already exists). The three sections of general interest are:

1) Design criteria and tables for making design calculations for low-pressure systems,

2) Examples of water system designs, including several solar water heating, natural gas and biogas installations, and

3) Drainage requirements for drains and sewers.

There are many detailed system design drawings and design tables included. This reference is meant for buildings in a city like Kathmandu, where water distribution systems already exist or will exist in the near future.

The special value of this manual is that it represents an adaptation of standard plumbing design and practice to some of the materials, tools, and building construction practices found locally in Nepal.

Hand Dug Wells and Their Construction, **Disk 12, File 13-331**, book, 234 pages, by S. Watt and W. Wood, 1977, £7.95 from ITDG; also available from VITA and TOOL.

"This manual describes hand dug shaft wells and their construction by relatively unskilled villagers. Modern concepts, methods and designs are incorporated, but in such a way that those who will carry out the actual work do not require a high degree of education, training or supervision. Much of the equipment can be made locally and costs (especially the cost of imported materials) can be kept to a minimum. The simple directions are based upon proven methods and satisfactory results gathered from various parts of the world. Wells constructed by the methods indicated need be in no way inferior to those produced by mechanical. equipment at many times the expense."

"The first part of the book deals with the general principles of ground water storage, hygienic sources, and some notes on the preparatory work. Part II deals with the actual construction, and Part III with alternative methods and techniques. Part IV details the standard equipment and materials used, and Part V provides additional information and sources." There are many drawings and photographs.

The best book on low-cost wells. Highly recommended.

Hand Drilled Wells: A Manual on Siting, Design, Construction and Maintenance, **Disk 12, File 13-352**, book, 132 pages, by Bob Blankwaardt, 1984, Rwegarulila Water Resources Institute, Tanzania, Dfl. 19.50 from TOOL.

Hand-drilled wells are interesting because they are low-cost, both in terms of the equipment required and the cost of sinking individual wells. The equipment has the additional virtue of being very portable, allowing it to be carried by pack animals into locations inaccessible to truck-mounted rigs. Hand-drilled wells are, however, more limited by depth and rocky soils than wells sunk by motorized rigs. In practice, hand-drilled wells tend to be clustered in areas with known water table and soil characteristics, and there is often a local tradition of sinking these wells.

This volume goes beyond the limitations of local well-drilling wisdom by providing a basic understanding of groundwater and site investigation. This will allow the reader to strike out into new territory and identify likely sites for hand-drilled wells. Detailed information is provided on drill bit design, drilling techniques, installation of the filter pipe and the pump itself, and maintenance of the pumps. All of these topics are covered with numerous photos and illustrations.

Well Construction Using Curved Hollow Block, **Disk 12, File 13-351**, book, 115 pages, by C. Gampher and S. Gates, 1989, $3.00 from Haribon Foundation, Suite 306 and 304, Sunrise Condominium, 226 Ortigas Avenue, 1500 San Juan, Manila, Philippines.

A construction manual for an unusual hand-dug well construction technique, in which curved hollow concrete blocks are used to line the side of the well. "The technique is similar to the technique of using street culverts to form a cylinder. The

advantage of curved hollow block over culverts in remote sites is that two to three people can build a well from start to finish," without the heavy equipment needed to transport and position culverts. Excellent illustrations.

Self-Help Wells, FAO Irrigation and Drainage Paper #30, **Disk 12, File 13-343**, 78 pages, by R.G. Koegel, 1978, reprinted 1985, $8.00 from FAO or $12 from UNIPUB.

This is a good survey of self-help well-drilling and digging techniques. The emphasis is on local materials and labor, not on imported technologies. Techniques are described for both small (15 cm) and large-diameter wells. Drilling methods discussed include boring, percussion and rotary drilling for small-diameter wells. Excavation techniques for larger diameter wells are presented.

The amount of detail in descriptions varies, but there are many good drawings. Even though this is not a construction manual, these drawings are very useful in explaining the ideas. The materials range from simple wooden tools to metal drill bits, making these techniques adaptable to a wide variety of local conditions. Labor-intensive techniques are emphasized. Also included are sections on health aspects of drilling, how to find water that is likely to be uncontaminated, safety precautions while drilling, and non-vertical wells (e.g. Qanats horizontal tunnels that intercept a sloping water table).

Wells Construction: Hand-Dug and Hand-Drilled, Peace Corps Appropriate Technology for Development Series, **Disk 12, File 13-348**, book, 282 pages, by Richard E. Brush, 1980, available to Peace Corps volunteers and development workers from Peace Corps; also available from ERIC (order no. ED241770) and from NTIS (accession no. PB87-226064).

This is a well-written manual covering planning, design, and construction of small wells. Both hand-dug and low-cost drilling methods are discussed in a manner understandable by people new to the field. Appendices include an introduction to cement and concrete, techniques for using vegetation to locate water, uses of dynamite for well construction, a survey of common hand pumps, and instructions for chemical treatment of well water.

Water Wells Manual, **Disk 12, File 13-347**, book, 156 pages, by U. Gibson and R. Singer, 1971, Premier Press, Dfl. 32.75 from TOOL.

This is a "simplified, small wells how-to" manual. A good knowledge of English is necessary. It is intended as a "basic introductory textbook" to provide instruction and guidance to field personnel engaged in the construction, maintenance, and operation of small-diameter, relatively shallow wells used primarily for individual and small-community water supplies. ("Small" used here means up to 4 feet in diameter.) Topics include: background information on water cycles, geologic formations, water quality, ground water exploration, well design, well construction and maintenance, sanitation and wells, and a review of various types of pumping equipment and energy sources including a discussion of the advantages and disadvantages of each. This book would be useful for a community development worker who reads English well but has no formal training in water supply and/or well design. It is, however, oriented toward more technically minded people, even though it is described as "simplified."

E. Pumps and Water Lifters

Hand Pumps for Use in Drinking Water Supplies in Developing Countries, **Disk 12, File 14-355,** 230 pages, by F. Eugene McJunkin, 1977, revised 1983, International Reference Centre for Community Water Supply and Sanitation, out of print.

This is the basic reference book on handpumps, describing various types of pumps and principles of pump operation. It is "intended to serve public health officials, engineers and field staff who are planning and implementing water supply programs with hand pumps." Fewer pump types are described than in **Pumps and Water Lifters** (see review). The section on pump principles is detailed and technical, and includes design principles for each part of a pump assembly (plunger, stand, suction pipe, seals, valves, cylinders). It is a necessary reference for someone interested in detailed engineering design of simple pumps; many examples are given. There are two sections describing recent research in handpumps using wood, bamboo, plastic and steel, and local manufacturing methods for steel parts (such as casting, machining and welding).

A very complete, detailed handbook. Highly recommended.

Handpumps Testing and Development: Progress Report on Field and Laboratory Testing, World Bank Technical Paper No. 29, **Disk 12, File 14-365,** book, 399 pages, by Saul Arlosoroff et. al., 1984, $23.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

The UNDP/World Bank project for handpump testing has laboratory and field tested a large number of handpumps. A major purpose of the project has been to identify and help develop pumps that are "suitable for village-level operation and maintenance (VLOM)."

This report summarizes the field testing results on 2860 pumps of 76 pump types in 17 countries.

Also included is a 15-page description of the pvc Rower pump, a very low-cost pump used especially for small plot irrigation in Bangladesh, that has proved very popular.

"In order to achieve widespread, sustained coverage of the rural and urban fringe population, pump designs must be based on the VLOM principle. Only then will it be feasible to transform the maintenance system practiced in developing countries from a reliance on expensive motorized mobile teams of skilled mechanics paid with government funds to one where the village or a group of villages carries out and pays for pump maintenance and repair. Significant improvements in pump design have been made in this direction over the last few years, but no VLOM pump has reached the stage where it has become a production model with proven successful performance in field trials of adequate duration.

"Each country using handpumps will at some time have to decide which pump types to use. This choice will rarely be a single pump type. Nonetheless, standardization on a small set of pump types must be achieved for the sake of facilitating the distribution of spare parts, exercising stringent quality control of manufacturing, and training installers and village repairers. The ease with which pumps can be locally manufactured (including joint ventures) will be an important consideration in this process.

"The country-wide pump choice will depend on a variety of factors determined by local conditions, such as the range of water table depths, availability of alternative water sources, in-country manufacturing capability, self-help potential in villages, and user acceptability of pump types. To arrive at a selection, the performance of different handpumps must be evaluated in relation to local requirements. Future Project reports will present laboratory and field test results in a manner which will help the concerned organizations to make this choice."

See also the two books that follow, from the same series. Highly recommended.

Laboratory Testing of Handpumps for Developing Countries, World Bank Technical Paper No. 19, **Disk 13, File 14-366**, book, 267 pages, by the Rural Water Supply Handpumps Project, World Bank Publications, out of print.

The results of extensive laboratory testing of 18 handpumps from around the world are presented. The tests included an endurance test of 4000 hours of operation, and performance tests (of volume lifted, work input, leakage, and efficiency). Also included are user comments and an engineering assessment of the design and materials used.

This will be valuable reading to anyone designing pumps, as it identifies the failure points and problem areas in each design, as well as the successful features. Recommendations for improvements are also included. Many of these pumps are being made in the South.

Handpumps Testing and Development: Proceedings of a Workshop in China, World Bank Technical Paper No. 48, **Disk 12, File 14-364**, book, 240 pages, edited by Gerhard Tschannerl and Kedar Bryan, November 1985, $12.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

The Chinese contributions to these workshop proceedings indicate that they have been producing a surprising number of innovative and unique human and animal-powered pumps. Many of these pumps have been made in large numbers. In Hebei province alone, it is stated that there were "2,700,000 human and animal operated pumps, of which most were tube-chain water wheels" (also called "chain pumps"). Also unusual are a pedal-operated centrifugal pump and two designs of diaphragm pump (10,000 units sold in one year). These and other more conventional pumps are to be tested as part of the UNDP/World Bank project for laboratory testing of hand pumps.

The remainder of this book describes activities of international agencies and work in other countries; most of this material can be found in other sources.

Pumps and Water Lifters for Rural Development, **Disk 12, File 14-363**, book, 317 pages, by Alan Wood, revised 1977, $10 plus postage and handling in the U.S., outside the U.S. write to Publications, Engineering Research Center, Foothills Campus, Colorado State University, Fort Collins, Colorado 80523, USA.

A survey of water-lifting mechanisms in use around the world, from simple buckets to hydraulic rams and centrifugal pumps. The emphasis is on those that are built locally in developing areas, using local materials.

For each type of device, drawings, operating principles, and most appropriate conditions are given. Also included: discussions of historical uses of water pumps, prime movers (the energy source that powers a pump, from animal power and falling water to electric motors), criteria for choosing pumps for particular applications, general pumping principles with sample calculations, and how to read performance curves.

No detailed construction drawings are given. There are 123 clear illustrations, making this an excellent idea book for those who want to know what types of pumps are in use all over the world. It could serve as a starting point for someone to design and build his or her own pump for a particular application.

The Rower Pump, **Disk 13, File 14-368**, reports and brochures, 1984 and later, Mirpur Agricultural Workshop and Training School (MAWTS), Dhaka, Bangladesh, out of print.

Thousands of low-cost direct action handpumps made of pvc pipe are being used in Bangladesh for low-lift irrigation of small plots. The Rower pump can be easily made in developing countries, and the farmer can do his/her own simple repairs. The pump pays for itself in one crop.

The extremely low cost of the handpump (approximately US $15) and pvc tubewell installation (approximately US $30-45) and the large economic return from small plot irrigation together make this technology an excellent investment for farmers in areas where the water table is shallow (15 feet or less). The Rower pump is probably one of the most important agricultural tools invented in the last 20 years.

Readers seeking information on the Rower pump can write to the manufacturer (MAWTS) for a brochure with technical details. Some of the same material is reproduced in **Handpumps Testing and Development: Progress Report on Field and Laboratory Testing** (see review). The results of an extensive laboratory test are described in **Laboratory Testing of Handpumps for Developing Countries: Final Technical Report** (see review). The relevant pages from both of these books are reproduced in the A.T. Microfiche Library as **Disk 13, File 14-368**.

Chinese Chain and Washer Pumps, **Disk 12, File 14-349,** booklet, 49 pages, by S. Watt, 1976, out of print in 1985.

"This publication contains 21 versions of the chain and washer water lifting device, displayed at the 1958 Peking Agricultural Exhibition, in China. Each version of the pump was designed and built by separate communes, using local materials, skills and tools. A description of each pump with performance figures was written up in the simple information sheets that have been literally translated for this publication. The drawings presented are on the information sheets, and have been copied to allow anyone with a basic understanding of mechanics to build one of the devices; construction details are not included in this publication."

Each pump design listed has information on the rate of pumping and a summary of the construction method and materials. The introduction describes the principles of operation of chain and washer pumps, components of the pumps, design factors, and power sources available for water pumping (human, animal, wind, solar, and electric). The appendix includes 5 more pump designs, from India, France and Britain.

Community Water Supply: The Handpump Option, **Disk 13, File 14-371**, book, 202 pages, by Saul Arlosoroff, Gerhard Tschannerl, et. al., UNDP/World Bank, 1987, $9.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

A nice, thorough discussion of the requirements for VLOM (village-level operation and maintenance) of handpumps. The authors explore choice of technology and its reliability.

The book addresses the planning of projects to install hand pumps, including maintenance, well sinking, and finance. The technology section reviews the history of handpumps, lists factors that affect performance, and suggests guidelines for good design of pumps that are likely to do well under village conditions. The hand pump compendium describes and assesses dozens of pumps from around the world.

Water-Pumping Devices: A Handbook for Users and Choosers, **Disk 13, File 14-370,** book, 196 pages, by Peter Fraenkel, 1986 (reprinted 1990), FAO/ ITDG, £12.95 from ITDG.

Since irrigation has a dramatic effect on agricultural production, irrigation devices are usually the single most productive investment that can be made in small-scale agriculture. There are a great many different small water-lifting devices, traditional ones that often could be improved and modern ones that could be simplified to make them more affordable. This book does a nice job of reviewing them all in one place, making this an excellent starting place for comparing and choosing among them. Waterwheels, engine-driven pumps, hand- and foot-operated pumps, and solar pumps are all covered.

"The introduction of irrigation can double the labour requirements per hectare of land, and raise the incomes thereby not only of the farmers but also of landless labourers."

The general principles of water-lifting for irrigation, including system efficiency losses to be expected, are explored, followed by a thorough review of the many different water-lifting devices. Costs and alternative fuels are also discussed.

"The scoop wheel (sakia) ... widely used in Egypt ... has failed to become popular anywhere else. It is however an efficient and effective device. It consists of a large hollow wheel with scoops around its periphery, which discharges water at or near its hub rather than from its top. The diameters for sakias range from 2-5m; since water discharges at their hub level, the rule of thumb used in Egypt is that a sakia will lift water through a head of half its diameter less 0.7 m, to allow for the depth of submergence of the rim in order to scoop up water effectively. Therefore sakias of diameters from 2-5m will lift water from 0.3-

1.8m respectively. Sakias are normally made from galvanized sheet steel. Most sakias are animal powered, but they are increasingly being driven by either mains electric motors or small engines ... The best shaped designs were measured as being 50% better than the worst... Some 300,000 sakias are in use in the Nile valley."

Water Current Turbines: A Field Worker's Guide, **Disk 13, File 14-375**, book, 120 pages, by Peter Garman, 1986, £12.00 from ITDG.

The idea of powering water pumps with the energy from flowing water in rivers and streams has attracted the attention of A.T. enthusiasts for years. Most of these experiments with floating turbines have been hampered by problems of high materials use and thus high fabrication costs, flooding damage, awkward gearing, and the like. Here is a manual that should allow the reader to determine whether this is an appropriate technology for a local application, and if so, how to effectively make use of it. This volume was "based on four years' experience of designing, building and field testing water current turbines (WCTs). Nine different turbines have been built and field tested, for a total of 15,500 running hours, at Juba on the White Nile. This experience has shown WCTs to be technically and economically viable as an alternative technology to small diesel pumps in southern Sudan." The WCTs are used to pump irrigation water.

Two systems were developed based on the field experience. The Mark I machine, with a swept area of up to 5 square meters, can pump water through a lift of 5 meters at a maximum rate of 24 cubic meters per hour, depending on river.speed. The Low Cost version, with a swept area of up to 3.75 meters, can pump water through a lift of 5 meters at a maximum rate of 6 cubic meters per hour. Both machines can lift water to higher elevations and lower delivery rates. 1982 manufacturing costs in Sudan were $5000 for the Mark I, and $2000 for the "Low Cost" machines. Delivered water costs are compared with other water pumping alternatives.

This manual is not intended to be a construction guide, and the photos and drawings are incomplete in that regard.

Pump Selection: A Field Guide for Developing Countries, WASH Technical Report No. 61, **Disk 13, File 14-369**, book, 192 pages, by Richard McGowan and Jonathan Hodgkin, 1989, from Water and Sanitation for Health Project (WASH), 1611 North Kent Street, Room 1001, Arlington, Virginia 22209-2111, USA.

This is a book for anyone who wants to match pump selection to local conditions and resources. It "is intended to enable readers to understand better and evaluate more carefully the advantages and disadvantages of different types of pumping systems and their components (e.g., pumps, engines, and controls), associated costs, and long term operation and maintenance requirements."

The authors discuss diesel, wind, hand, and solar pumping systems; the local data required to make a technical comparison among these choices; and recent operating experiences with each.

"Solar pump costs depend primarily on two components the array size and the pumping unit. Solar module costs usually make up 60-85% of the total system cost and are usually quoted in terms of dollars per peak watt... In 1988, they were being quoted as low as US $4 per peak watt ... These prices usually do not include freight and insurance charges to ship to developing countries, which can easily add 50% or more to the price... Pump sets designed for use with PV systems range in price from US $1000 to US $3000 (FOB the manufacturer), with the units rated for lower power output costing less and often used at lower heads... Other costs associated with solar pumping systems include the array mounting structure, wiring, other types of controllers, water meters, civil works (e.g. a concrete pad for the array and piping), and storage tanks. These costs can vary considerably."

A Comparative Assessment of Photovoltaics, Hand pumps and Diesels for Rural Water Supply, **Disk 13, File 14-372**, book, 158 pages, by A. Cabraal et. al, 1987, printed copy code A08, available from NTIS.

Here is an interesting look at comparative costs for three different technologies providing the same level of service for rural water supply. The authors assume a village setting away from the electrical grid and away from safe surface water sources. The report identifies least-cost technology for various combinations of water depth, water demand, well cost, and village population size.

The authors conclude that photovoltaic (PV) systems are the least cost over a middle range of conditions (e.g., village of 1000 people, 20m water table depth). Handpumps are least cost with small populations and with medium populations where the water table is shallow. Diesels are least cost where there are larger populations, more water demand, and a deeper water table.

"Contrary to popular belief, in many cases, on a per capita basis even the initial cost of PV systems is equal to and even less than that of comparable hand pump rural water supply systems." This report also includes estimates of the total market for PV rural water supply systems.

Village Handpump Technology: Research and Evaluation in Asia, **Disk 13, File 14-367,** book, 72 pages, edited by Donald Sharp and Michael Graham, 1982, Publication IDRC-204e, $4.00 from IDRC.

IDRC sponsored the development and testing of an innovative hand pump using low-cost PVC plastic materials for most of the parts. The above-ground components were different in each of the four countries in which testing was conducted, while the below-ground components were the same. This volume summarizes the results of the field testing during the early 1980s.

Hydraulic Rams: Consumers Guide, booklet, 19 pages, by P. de Jong, 1987, and **Hydraulic Rams**, booklet, 12 pages, by J.H.P.M. Tacke and C. Verspuy, 1989, both Disk 12, File 14-373, free from Centre for International Cooperation and Appropriate Technology (CICAT), Delft University of Technology, P.O. Box 5048, 2600 GA Delft, The Netherlands.

The first booklet reviews the applications for hydraulic rams and provides some interesting and unusual laboratory test results comparing the performance of 12 hydraulic rams from six commercial manufacturers. The addresses of 19 manufacturers are also provided.

The second booklet reviews the operation of a typical hydraulic ram.

A Manual on the Hydraulic Ram Pump for Pumping Water, **Disk 12, File 14-358**, booklet, 37 pages, by S.B. Watt, 1978, £4.95 from ITDG; also available from TOOL.

The hydraulic ram is a device that makes water pump itself. It pumps only a small percentage of the water that flows through it, but it does so to a level that is much higher than the source. It can, for example, be used to pump water to a house on a small hill above a creek. The power source is the water moving through the pump.

"We have written this manual primarily to show field workers how they can design and construct a simple ram pump from commercial pipe fittings, how to choose a suitable site for the ram, how to install and adjust the ram, and the sort of maintenance the pump will need during its working life. We have tried to write the manual in non-technical language so that it can be used by people with little or no technical training; this information makes up Part I. In Part II, we describe in greater detail the range of operation of ram pumps, and the different materials that have been used to make them." This part of the manual explains the calculations necessary to design a ram.

"In places where this ram can be used, it has many advantages over other pumps powered by hand, animal, wind or motors, despite the fact that a lot of water passes through it without being pumped:

a) it does not need an additional power source and there are no running costs,

b) it has only two moving parts, and these are very simple and cheap to maintain,

c) it works efficiently over a wide range of flows, provided it is tuned correctly,

d) it can be made using simple workshop equipment."

The Construction of a Hydraulic Ram Pump, **Disk 12, File 14-350,** booklet, 36 pages, by Allen Inversin, 1978, Appropriate Technology Development Unit, Papua New Guinea, out of print in 1985.

The author intends this to be built by someone with very little machining experience; however, "... it is quite probable that those who have had machine shop experience will prefer alternative means of construction (rather than the simple ones described in the manual)." Very simple yet detailed instructions, easily the clearest we've seen, are given, along with clear illustrations. Construction is simple, as only hand tools and a drill press are necessary. In addition to commercially available pipe fittings, small strips of scrap steel, nuts, bolts and epoxy are the only materials required. A significant part of this manual is the 8 pages devoted to performance information, based on a year of testing and improvement in PNG. The pump has been tested at drive heads (heights) of 1/2 to 4 meters. For delivery heads of 10 times the drive head, it can deliver 3600 liters of water a day. Graphs for predicting performance at various operating heads are included.

Use of Hydraulic Rams in Nepal: A Guide to Manufacturing and Installation, **Disk 12, File 14-362**, booklet, 46 pages, by Mitchell Silver, UNICEF, Kathmandu, Nepal, out of print.

This book includes what **Construction of a Hydraulic Ram Pump** (see review) does not: how to install, use and maintain a hydraulic ram after you've built or bought one. It is written in plain English.

Although aimed at local conditions in Nepal (for example, the availability of supplies in Kathmandu hardware stores is discussed), this book is useful for anyone with little mechanical background who wants to use a hydraulic ram in any location.

Included are chapters on how a hydraulic ram works, surveying a site, descriptions and design considerations for intake tanks, reservoirs, operating a ram pump, maintenance and repair. Conversion tables are included. There are 14 pages on building a ram pump using standard pipe fittings. The valves can be either bought or made. The instructions and drawings

are not as detailed as in other hydraulic ram publications, but they could be used by someone with mechanical experience. The most useful part of this booklet, however, is that it shows how hydraulic rams can be simply adapted for use in differing local conditions.

Recommended for use with a hydraulic ram construction manual.

Popular Mechanics Hydraulic Ram, Reprint No. X346, **Disk 12, File 14-360**, article with plans, 11 pages, by C.A. Crowley, $8.25 plus postage from Popular Mechanics Plans, Dept. 77, Box 1014, Radio City, New York 10101, USA.

This reprint from **Popular Mechanic**s, a magazine, has two parts. The first explains the operation of a hydraulic ram, simplified methods enabling anyone to determine how much water can be lifted from a stream to the place where it will be used, how to measure the amount of water flow in the stream, and where and how to install the pump. The second part describes a design for a ram pump made from standard plumbing parts. The drawings and construction are clear. The materials and.production processes required may not be locally available everywhere.

Manual of Information: RIFE Hydraulic Rams, **Disk 12, File 14-357,** booklet, 15 pages, 1985, free from Rife Hydraulic Engine Manufacturing Company, P.O. Box 857, Montgomeryville, Pennsylvania 18936, USA.

This pamphlet covers the information you need to install a ram: where to place it, how to estimate the water output, how to measure the flow, choosing the size for the drive and delivery pipes. Describes the operation of a ram, but does not describe a ram design. The information is for use with rams manufactured by Rife; other ram designs will have somewhat different performance.

Women and the Transport of Water, **Disk 13, File 14-374**, book, 54 pages, by Val Curtis, 1986, £6.50 from ITDG.

"Women in rural areas of developing countries have a heavy workload ... One of their most arduous and time-consuming daily tasks is the haulage of water from often distant sources. Ideally each household would have a modern source in or near the home but this is a long way from being achieved. In fact, in many developing countries improvements in water supply are not keeping pace with population growth, so more rather than fewer women are having to carry water. This paper looks at some of the problems women have with this work and investigates whether improved means of transport could help relieve their burden." A collection of low-cost water hauling aids, containers, and systems from around the world is presented.

F. Storage Tanks

Ferrocement Water Tanks and Their Construction, **Disk 13, File 15-365**, book, 118 pages, by S.B. Watt, 1978, £4.95 from ITDG; also available from TOOL.

The book covers a number of different ways to use ferrocement (wire-reinforced cement mortar) to construct water storage tanks and jars of many shapes and sizes. The author has worked with ITDG for years and has written a book that thoroughly covers design, construction and use of ferrocement water storage containers. The book is an excellent construction manual, but it also covers catching and using rainwater from roofs and land surfaces, health aspects of water storage, use of ferrocement linings for earthen tanks, and sources of further ferrocement information. There are many detailed photos and illustrations.

"The Dogon people of Mali, living in the Sahelian drought zone with a rainfall of only about 40 cm (16 in.) per year, suffer greatly from water shortages during the dry season. The method of storing water described in this chapter was devised to provide a cheap tank for water collected from the flat roofs of the houses. The water tanks, which consist of traditional (adobe) grain bins, lined with a thin layer of reinforced (ferrocement) mortar, are readily acceptable to the users and fit well into their social and cultural visions of life."

This book seems to contain all the information one would need to build ferrocement water storage tanks. The water tank construction techniques would also be useful to someone building other types of ferrocement structures such as grain.bins or houses. An excellent book, highly recommended.

Construction Manual for 3500 gal. Ferrocement Water Tank, **Disk 13, File 15-364** pamphlet, 19 pages, by E.H. Robinson, $2.50 from Caribbean Appropriate Technology Center, Caribbean Council of Churches, P.O. Box 616, Bridgetown, Barbados.

This construction manual is best suited for people who have had experience working with ferrocement, as the instructions and illustrations are sparse, although generally quite clear. People without prior experience in this area should check more detailed references on the topic (see, for example, **Ferrocement Water Tanks and Their Construction**).

Bamboo-Reinforced Concrete Rainwater Collection Tanks, **Disk 13, File 15-367**, booklet, 50 pages, by Thomas Fricke, ATI, 1982, accession no. PB-85 224830/ AS paper edition $12.95, microfiche $6.50, from NTIS.

Rainwater catchment tanks are proving to be a popular, affordable technology in Northeastern Thailand, where some 2500 11-cubic meter tanks have been constructed between 1978 and 1982. Villagers are paying for these tanks through loans provided by the implementing agency and by providing some of the construction labor themselves. The loans are being repaid on time. The unusual organizational structures involved and some interesting conclusions and implications for other technology dissemination programs are described. Some construction details are provided, but this is primarily a review of the program and the process, rather than a how-to-do-it manual.

From Ferro to Bamboo: A Case Study and Technical Manual to a Rain Water Catchment Project, **Disk 13, File 15-366**, booklet, 48 pages, by Marcus Kaufman, 1983, $12.00 postpaid from Publication Section, Yayasan Dian Desa, P.O. Box 19, Bulaksumur, Yogyakarta, Indonesia.

Finding that the high cost of materials for ferrocement water catchment tanks in Central Java was limiting the tank's dissemination to projects with outside funding, Yayasan Dian Desa developed a bamboo-reinforced tank which is based on technologies already in use locally. Although the design proved to be popular and technically suitable, Dian Desa's evaluation team found that many tank owners would exhaust their convenient supply of tank water soon after the rainy season, when other sources of water were still available. This left the tanks empty through the critical summer months of water scarcity, defeating the major purpose of the tank building program. Clear instructions and drawings show how to build the 4.5 cubic meter "single family" bamboo cement water catchment tank described in the case study. Highly recommended.

G. Filtration and Treatment

Water Treatment and Sanitation: Simple Methods for Rural Areas, **Disk 13, File 16-381**, book, 96 pages, by H. Mann and D. Williamson, 1973, revised edition 1982, £5.95 from ITDG; also available from VITA and TOOL.

This is still a good introductory book on these subjects, but many of the newer books reviewed here go into much greater depth on narrower topics. Includes chapters on selection of source and simple water testing, water supply, water treatment, excreta disposal, sewage treatment, temporary and emergency treatment. Charts, graphs and simple methods for roughly calculating water demand, flow measurement, and pump heads are included, as are simple drawings of a variety of water system equipment: sand filters, pumps, privies, water seal toilets, and simple sludge treatment ponds. A glossary of technical terms is included, as are drawings and a bibliography.

Slow Sand Filtration, **Disk 13, File 16-376**, book, 115 pages, by L. Huisman and W. Wood, 1974, stock no. 1150144, $12.80 (30% discount on orders from developing countries) from WHO; also available in French; also available from ITDG.

The slow sand filter is one of the best means of treating a raw water supply where specialized chemical technology is not available. Far from being an old-fashioned technology, the authors feel that the slow sand method can be the cheapest, simplest and most efficient method of water treatment.

Several scales of design are discussed and illustrated, although knowledge of basic engineering mathematics would be helpful. The last part of the book discusses the use of sand filters for recharging groundwater, an important consideration for arid areas. In areas of known biological contamination, however, the use of chemical treatment (chlorine or preferably iodine) along with sand filtration would provide a very safe water supply. Slow sand filtration methods are also very simple to operate: "Provided that a plant has been well-designed and constructed there is little that can go wrong as long as the simple routine of operation is carried out."

A very valuable book for those involved with planning water supplies for small to medium size communities.

Slow Sand Filtration for Community Water Supply in Developing Countries: A Design and Construction Manual, Technical Paper No. 11, **Disk 13, File 16-378**, book, 178 pages, by J.C. van Dijk and J.H.C.M. Oomen, 1978, IRC, out of print.

"Although the field of water treatment offers a variety of technological choices, only a few of them can in principle fully meet the specific requirements of developing countries. One such method is slow sand filtration a simple, efficient and reliable technique for the treatment of water. Its costs generally lie within the resources of the community and/or country and the skills for design, construction, operation, and maintenance are usually available locally or can be fairly easily acquired."

Slow Sand Filtration for Community Water Supply in Developing Countries, Bulletin No. 9, **Disk 13, File 16-377**, annotated bibliography, 61 pages, by H. Hartong, 1978, IRC, out of print.

Slow sand filters have been in use for almost 150 years in public water supplies. Even though some European cities use them on a large scale, they tend to be dismissed as old-fashioned or out of date. However, many people are once again concluding that slow sand filtration for purifying drinking water is very effective, and deserves more widespread use, particularly in rural and urban fringe areas of developing countries.

This bibliography contains 79 entries on the technical aspects of slow sand filtration. Each entry is summarized and indexed according to author and keywords. Included is a list of institutions around the world active in developing low-cost slow sand filtration methods.

L. Huisman notes in the preface: "In developing countries ... slow sand filtration is often applied as a single treatment process, only where necessary preceded by a simple pre-treatment for turbidity removal. Optimal use can be made of locally available materials such as bricks, mud blocks and mass concrete, while also filter sand of good specifications is readily available in most countries. Operation and maintenance are relatively easy and can be done by semi-skilled operators. Operational costs are minimal, the more so as no chemicals are required. Slow sand filtration may be regarded as an appropriate water treatment process and its wider application may considerably contribute to an improved provision of safe drinking water in developing countries."

An extensive, excellent bibliography.

Slow Sand Filtration for Community Water Supply: Planning, Design, Construction, Operation and Maintenance, Technical Paper No. 24, **Disk 13, File 16-383,** book, 149 pages, by J.T. Visscher et. al., 1987, from IRC.

This contains more direct examples from developing countries than other slow sand filtration books we have included. Five standard designs for small-scale systems are presented, along with general guidelines on design, construction, estimating costs, operation and maintenance (including cleaning and washing sand).

Solar Disinfection of Drinking Water and Oral Rehydration Solutions, **Disk 13, File 16-382,** book, 56 pages, by Aftim Acra, Zeina Raffoul, Yester Karahagopian, American University of Beirut, available from UNICEF, P.O. Box 811721, Amman, Jordan.

The disinfection of drinking water and oral rehydration solutions normally requires boiling or the use of chemical agents. Here is an interesting technique by which water placed in glass and plastic containers and exposed to sunlight can be freed of living bacteria. "The time required to kill 99.9% of coliform bacteria by exposure to sunlight" was found to have a mean value of 85 minutes. Colorles glass and plastic containers were found to be better than colored containers. The authors did not study the effects of sunlight on protozoa and enteric viruses.

For family use, the authors recommend that enough drinking water for several days be placed in these transparent containers, and exposed for a full day, then allowed to cool indoors. "In such emergencies as when a family runs short of disinfected drinking water, an exposure period of about two hours, especially at.noontime, should be adequate for proper disinfection."

Simplified Procedures for Water Examination, Manual M12, **Disk 13, File 16-375**, laboratory manual, 190 pages, 1978, $25.50 member price, $31.50 non-members, plus $2.25 shipping for single copy, from American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235-3098, USA.

A detailed, step-by-step laboratory manual for testing water quality, using modern laboratory equipment. Chemical, bacteriological and biological (microscope) examinations are all discussed. Chemical tests can be used to determine whether too much or too little disinfectant is being added to water. Bacteriological tests determine the presence of coliform bacteria, which can make drinking water unsafe. Useful only in areas where laboratory facilities already exist.

The Purification of Water on a Small Scale, Technical Paper #3, **Disk 13, File 16-373**, booklet, 19 pages, 1973, IRC, out of print in 1985.

This short booklet contains practical instructions for water purification by boiling, chemical disinfection and filtration. Chemical disinfection includes chlorine, iodine and potassium permanganate (not recommended). Filtration methods include sand filters for coarse filtration, and ceramic filters for finer filtration. A simple filter design is given. This sand filter removes visible dirt and particles such as ova and cysts; the authors say it won't remove bacteria. The importance of storage in preventing recontamination of water is emphasized.

Solar Distillation as a Means of Meeting Small Scale Water Demands, **Disk 13, File 16-379**, book, 86 pages, 1970, reprinted 1977, pub. no. 70.11.B.1, UNIPUB, out of print.

Solar distillation is an elementary process: salt water or polluted water is placed in a container under a transparent cover. This cover traps solar energy which heats the water. The water evaporates and then condenses on the inside of the cover, and the impurities are left behind. This condensed water can be collected and used for drinking and cooking. However, only small quantities of water are produced (about 25-30 gallons per square foot of still per year). Solar distillation is therefore an expensive technology in terms of cost per gallon of water. It is a real option primarily in island and arid coastal locations where surface or groundwater sources of fresh water are not available. In many of these places, rainfall is significant during part of the year, and rainwater catchment systems may be a more economical alternative to provide at least part of the water needed.

This is an excellent manual on all sizes of solar distribution plants, for providing fresh water in small communities. The purposes of the manual are: "to review the current status of solar distillation, outline the general situations where it may be the best solution to water supply problems, provide a method for potential users to estimate performance and costs of current still designs in their area, to note practical problems of solar still design and operation, and to recognize possible changes in solar distillation technology and economics which may affect the applicability of the process in the future." Very good information on the design of stills is included, requiring a knowledge of basic mathematics. There is a lack of detailed plans, but construction of stills using the ideas and drawings in the book is possible. The major requirements for a solar still are simply a basin of cement or other material to catch water, and a clear covering of glass or plastic.

How to Make a Solar Still (plastic covered), **Disk 13, File 16-370**, dimensional drawings with text, 13 pages, Brace Research Institute, 1965 (revised 1973), $1.75 from BRACE.

"This leaflet permits the user to make a relatively inexpensive solar still, primarily out of plastic sheets and bricks. It is not what might be recommended for a long-term installation. However, this plastic covered unit can certainly be adequately used for temporary installation."

"It has the advantage of being suitable for units producing anywhere from 1 gallon to 1000 gallons per day, and will operate for long periods in isolated locations without attention. No auxiliary power source is needed, other than means for feeding water into the unit .... 12 square feet of solar still area are needed to produce one gallon of water daily." A 400 square foot still in the West Indies cost US $228.00 for materials.

To really use this leaflet well, one would have to improvise considerably. The size they chose is 100 feet long, with a concrete base hardly a temporary enterprise yet the plastic sheeting will last only 6 months to 2 years even though it represents /2 the cost of the materials. The task of replacing it is easy.

Simple Solar Still for the Production of Distilled Water, Technical Report No. T17, **Disk 13, File 16-374**, 6 pages, by T.A. Lawand, 1965 (revised 1967), also available in French and Arabic, $1.75 from BRACE.

This unit was "designed primarily for use in service stations with the object of providing distilled water for automobile batteries." Distilled water is very necessary for battery maintenance, especially in arid regions. This still will produce an average of 3 liters per day.

Clean fresh water (can be collected on roof during rainy season) is added to the still each day distilled water is drained off. Users must be careful with the storage of the distilled water to avoid contamination.

Plans for a Glass and Concrete Solar Still, Technical Report No. T58, **Disk 13, File 16-372**, 8 pages of text plus 2 large blueprints, by T.A. Lawand and R. Alward, 1972, $4.50 from BRACE.

"This report contains a series of plans and specifications for a solar distillation plant designed by the Brace Research Institute for a site in Haiti." The average output is 200 gallons of distilled water per day. "The units are simply built and, apart from plumbing, are composed of four components: concrete curbs, a butyl rubber basin liner, glass panes for the transparent cover and a silicone glass sealant." This system is actually a series of solar stills connected together.

Installation of a Solar Distillation Plant on Ile de la Gonave, Haiti, Internal Report No. 167, **Disk 13, File 16-371**, 10 pages plus 10 photos, by R. Alward, 1970, BRACE, out of print in 1985.

This report covers the actual installation of the glass and concrete solar still for which plans are given in the above Technical Report No. T58. Illustrates point by point the problems encountered in the actual construction and the solutions that were found. There are 10 excellent photographs showing the method and stages of construction.

H. Sanitation

Low-Cost Technology Options for Sanitation: A State-of-the-Art Review and Annotated Bibliography, Appropriate Technology for Water Supply and Sanitation Vol. 4, **Disk 13, File 17-387,** book, 184 pages, by Witold Rybezynski, Chongrak Polprasert, and Michael McGarry, 1978, World Bank Publications, out of print.

This is a sourcebook on sanitation alternatives. The first quarter of the book is a review of the existing methods for collection, treatment, reuse and disposal of human wastes.

"There exists a wide range of effective alternatives between the unhygienic pit privy and the Western water-borne sewerage system. These systems are generally far cheaper. Most of them do not demand a heavy use of water. And many make creative use of the nutrients in human waste to fertilize fields and fish ponds or to contribute to biogas production and they can do this without serious risk of returning pathogens to human food or drinking water."

The bibliography fills the rest of the book. Thousands of pieces of literature were examined in the process of choosing 530 documents summarized here. "Emphasis has been placed on technological issues, but institutional, behavioral, and health-related aspects of excreta disposal were also considered." Most of this literature is available only in English, but some of it is also available in Spanish, French, Norwegian or Swedish.

Very little documentation of indigenous excreta disposal practices exists, the authors note. "It has been assumed that these (practices) are of little importance as they will eventually be replaced by sewerage. As a result, the potential for upgrading existing practices has been largely ignored .... Once existing conditions are understood as a starting point, certain solutions will be more compatible with resources available. Particular options will integrate reuse possibilities that reflect energy, food, or agricultural needs of the particular community. Whether such solutions lead to water-borne sanitation is less important than the fact that they will be the beginning of a dynamic process of development."

Unfortunately there are no prices listed, and most source addresses given are incomplete. This will make acquisition of the documents difficult. There is a thorough index and an excellent glossary of sanitation terms.

Highly recommended.

Small Scale Sanitation, Ross Bulletin No. 8, booklet, 54 pages, by R. Feachem and A.M. Cairncross, 1988, £3.00 from Ross Institute, London School of Hygiene and Tropical Medicine, Keppel (Gower) Street, London WC1E 7HT, England; or ITDG.

This booklet presents "the range of technologies available for excreta disposal in small communities and describes each system in simple terms. Design formulas are included where appropriate and (for experienced people) it is possible using this booklet to design the main elements of the systems."

Two chapters cover individual components and complete waste systems, from bucket latrines to water seal privies and septic tanks. The information here is largely descriptive. A third chapter covers the design and construction of squatting slabs, pit latrines, water privies, septic tanks, soak ways (leachlines or drainfields), and waste stabilization ponds.

A good mix of description and design details is presented. The book's strongest point is that it concentrates on rural, tropical areas in developing countries, analyzing what is and what isn't appropriate. (For example: the Clivus Multrum self-composting toilet "has not yet proved its worth in the tropics or among low-income communities.")

Recommended.

Excreta Disposal for Rural Areas and Small Communities, World Health Organization Monograph No. 39, **Disk 13, File 17-392**, book, 176 pages, by E. Wagner and J. Lanoix, 1958 (reprinted 1971), order no. 1140039, $22.40 (30% discount to developing countries) from WHO; also available in French.

This is a solid reference work on the disposal of human wastes. 100 pages are given to various privy methods of waste disposal; advantages and disadvantages are given for each method considered. Water-carried methods and considerations are similarly treated with 35 pages. The many drawings generally include enough information for local construction.

Much of the material presented in this excellent but high-priced manual is covered by other sources **(Village Technology Handbook, Stop the Five Gallon Flush, Septic Tank Practices**) which cumulatively give more information.

The Co-Composting of Domestic Solid and Human Wastes, World Bank Technical Paper No. 57, **Disk 13, File 17-412**, book, 101 pages, by Letitia Obeng and Frederick Wright, 1987, $7.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

"Urban areas are finding it increasingly difficult to safely dispose of human wastes and domestic solid wastes. It is also becoming increasingly important worldwide to improve the nutrient and physical qualities of agricultural soils. This is especially true in the food production areas surrounding growing urban centers in developing countries." This report explores the potential and requirements for co-composting, "a process that can convert more than one waste, such as human and domestic solid wastes, into a useful resource." Pathogen destruction, composting systems, and uses of compost are reviewed. A methodology for evaluating the economic feasibility of co-composting is presented. For these calculations, costs of atypical facility are suggested, and a computer model that can be run on microcomputers is available to interested parties.

Goodbye to the Flush Toilet, **Disk 13, File 17-393,** book, 296 pages, edited by Carol Hupping

Stoner, 1977, RODALE, out of print. "A waste is a resource out of place." This book describes the best biological systems developed during the early 1970s in North America for on-site recycling of human wastes and waste water (greywater). Numerous designs are presented, with

text and drawings that would allow readers to build or maintain such devices. The Farallones Institute vault and drum privies, Ken Kern's solar shower and privy, the Clivus Multrum and other manufactured units are featured. This book is written primarily from a North American context and is probably most valuable in temperate regions and industrialized countries,

An essay by Witold Rybezynski describes an experimental dry toilet design tested in the South: "The Minimus chamber is built out of cement blocks, plastered inside, and has a concrete bottom. The vent pipe is galvanized metal, and the air ducts are PVC. The total material costs (not including labor) was US $55. The construction time was six man-days."

"It should be stressed that there is no one 'design' for the Minimus. It must be adapted to meet local climatic conditions, available building materials, local skills, and conditions. The application of composting sanitation technology to developing countries cannot be on a piecemeal basis. It must be done on a community (not individual) scale and integrated with social and education development. It was precisely in such a way that rural composting toilets were introduced to North Vietnam during the years 1961-1965."

Sanitation in Developing Countries, **Disk 13, File 17-396**, book, 172 pages, 1981, IDRC, out of print;

French edition may still be available from IDRC Experience with many levels of sanitation technology in a variety of African nations is presented in this record of the proceedings of a regional workshop held in Botswana in 1980. Notable for the clear-sighted appraisal of what works and what doesn't in a given cultural, technical and economic setting, the papers draw well-considered conclusions that are applicable to a broad range of village improvement efforts, especially those that require community cooperation.

Recommended.

Sanitation Without Water, **Disk 13, File 17-397**, book, 133 pages, by Uno Winblad and Wen Kilama, 1985, MacMillan, Dfl. 17.50 from TOOL.

"The flush toilet cannot solve the problems of excreta disposal in the poor countries. Nor has it indeed solved those problems in the rich part of the world." To document some alternatives, the authors have written this practical manual on waterless waste treatment systems, primarily compost privies and pit latrines for individual households. These units do not require water-borne sewage disposal lines and are thus less expensive and complex.

The information presented here is intended for health officers, medical workers, and village technicians in East Africa, although the authors feel the information is adaptable elsewhere. The book should also be useful as a guide in training programs. There are four parts:

1) The relationship between sanitation and disease; the digestion and composting processes;

2) a description of 10 dry sanitation systems around the world (for a more extensive summary, see **Stop the Five Gallon Flus**h);

3) a latrine manual, including explanations of latrine components, design information, operating instructions, and proper location for latrines;

4) appendix: fly control in dry latrines.

The authors also add a note of caution: "There are no miracle solutions to the problem of excreta disposal .... The methods and systems described can work and some do work very well indeed. But when not fully understood by the users or constructed in the wrong way or in the wrong place, they may fail completely."

The best (and only) book we've seen that covers all aspects of dry sanitation systems on an easily understood level. The 97 drawings are very helpful in understanding these simple methods of sanitation that can be applied with limited resources.

Highly recommended.

Appropriate Technology for Water Supply and Sanitation, series of books published by the World Bank, most out of print, Volumes 1b,2, and 3 available from World Bank.

This series reports the findings of a two-year World Bank study on appropriate technology for water supply and waste disposal in developing countries. "The objective of the project was to identify and evaluate sanitation technologies for their potential to meet the needs and match the resources of project beneficiaries." Consideration is given to a wide range of technical, economic, and social factors relevant to a choice of traditional or "improved" technologies. The series will eventually include 14 volumes.

Vol. 1: **Technical and Economic Options** (**Disk 13, File 17-382)**

Vol. 1a: **A Summary of Technical and Economic Options** (**Disk 13, File 17-383**)

Vol. 1b: **Sanitation Alternatives for Low-Income Communities A Brief Introduction** (**Disk 13, File 17-384**)

Vol. 2: **A Planner's Guide** (**Disk 13, File 17-385**)

Vol. 3: **Health Aspects of Excreta and Sullage Management A State-of-the-Art Review** (**Disk 13, File 17-386**)

Vol. 4: **Low-Cost Technology Options for Sanitation A State-of-the-Art Review and Annotated Bibliography** (**Disk 13, File 17-387**, see separate review)

Vol. 5: **Sociocultural Aspects of Water Supply and Excreta Disposal** (**Disk 13, File 17- 388)**

Vol. 10: **Night Soil Composting** (**Disk 13, File 17-389**).

Double Vault Composting Toilets: A State-of-the-Art Review, **Disk 13, File 17-403**, by Witold Rybezynski, in Environmental Sanitation Reviews, No. 6, December 1981, journal, 27 pages plus appendix, available for approximately $8.00 from Environmental Sanitation Information Center, Asian Institute of Technology, P.O. Box 2754, Bangkok, Thailand.

Double vault composting toilets are attracting considerable attention due to their low cost, simplicity, and large-scale successes reported from India and North Vietnam. The author of this review provides an enlightening and entertaining review of the history and variations among the major design options.

"The necessity for constructing a slab to span the composting vaults, which is both expensive and complicated (as well as using reinforced concrete), is neatly avoided in the sopa sandas (simple latrine). The pits are offset from the squatting plate and an inclined chute connects the two ... installations have used baked earthen pans and chutes, as well as more expensive glazed ceramic .... The organic refuse is added to the vault all at once, before it is used, rather than continuously. When the vault is filled it is sealed, organic refuse added to the adjoining vault, and the adjoining pan is used. The vaults have no bottoms and excess liquid is infiltrated into the ground. No vent pipes are required. The sopa sandas has a number of advantages: extremely low cost through offsetting the vaults and eliminating vent pipes; simple operation since organic waste is only added once every six months; it easily accepts anal cleansing water since the floor of the vaults is permeable. The sopa sandas DVC toilet has been in continual use in India for the last 20 years, and has been popularized by such volunteer organizations as Maharashtra Gandhi Smarak Nidhi, which ... by 1980 had built 60,000 latrines in Maharashtra state."

Dry Composting Latrines in Guatemala, **Disk 13, File 17-404**, paper, 15 pages, by A. van Buren, J. McMichael, A. Caceres, and R. Caceres, CEMAT, Guatemala, 1982, out of print.

Double vault dry composting latrines reached widespread acceptance in North Vietnam during the period 1958-78, and reportedly greatly reduced the incidence of intestinal diseases while providing valuable fertilizer. This report describes an attempt to achieve similar benefits using a Guatemalan design and local materials. The authors indicate that significant local interest has led to latrine construction in at least 10 highland villages.

How to Build a Pit Latrine, Disk 13, File 17-405, booklet, 46 pages, available free on request from UNICEF, P.O. Box 1187, Kathmandu, Nepal.

A well-illustrated booklet in Nepali and English, showing step-by-step construction of a very simple pit latrine made of local materials.

Sanitation Handbook (Nepal), **Disk 13, File 17-400**, book, 59 pages, by Martin Strauss, 1982, Community Water Supply and Sanitation Program (SATA), SKAT, out of print.

A reference book for latrine construction in Nepal, including a local version of the Zimbabwe ventilated spiral latrine. Describes the transmission of pathogens commonly found in Nepal.

Compost Toilets: A Guide for Owner-Builders, **Disk 13, File 17-390**, book, 51 pages, 1979, National Center for Appropriate Technology, P.O. Box 3838, Butte, Montana 59701, USA, out of print.

The water-borne sewage system is the standard technology for safe disposal of human wastes in urban areas in the industrialized countries. These systems are extremely expensive to build and operate. By 1978, the capital investment necessary to connect one house to such a system in the U.S. was reported to be a minimum of $4000. A substantial amount

of water, 25-60 gallons per person per day, is required to flush the toilets. Treatment of the sewage is also costly, energy-intensive, and represents the destruction of a potential resource.

In many areas both inside and outside the United States, a dry composting toilet appears to be a much more economically and environmentally-sound alternative. **Compost Toilets** is a well-organized introduction to the subject. It explains the composting problems associated with the major designs. Draining systems and simple jar fly traps are shown that have been successfully developed to overcome the common problems of liquid buildup and flies. There are three complete slant-bottom designs presented for owner-builders, with discussion of the pros and cons of each.

"A compost toilet ... can be a safe and efficient, sanitary human waste treatment system. The main question facing owner/builders is whether they are prepared to take the time to manage the system efficiently." The right liquid and carbon/nitrogen balances must be kept or the toilet will not function properly. In.most designs, the composted material must be removed approximately every 3 months after the initial start-up period.

Costs of commercially-made compost toilets are given as $850 to $2500. Systems built at the site are expected to cost about $450 for materials and $500 for labor. We recommend this book to U.S. readers. Readers in developing countries should refer to the excellent **Double Vault Composting Toilets: A State-of-the-Art Review** and the other books reviewed in this section.

Ventilated Improved Pit Latrines: Recent Developments in Zimbabwe, **Disk 13, File 17-409**, booklet, 39 pages, by Peter Morgan and D. Duncan Mara, December 1982, Technology Advisory Group, World Bank, accession no. PB84220367/LL, $19.00 (microfiche only) from NTIS.

In Zimbabwe, 20,000 ventilated pit latrines have been built using an unusual doorless design. The authors estimate that 20-35 years will be required before a family of 6 manage to fill the pit. Urban designs of ferrocement or brick with pipe vents cost about US $160. The rural versions of mud and wattle, thatch, anthill soil, local bricks and timber are much cheaper, but require a minimum of 25 kg of cement. These designs are estimated to cost $8 for special materials plus local materials and labor.

The Design of Ventilated Improved Pit Latrines, **Disk 13, File 17-402**, booklet, 73 pages, by D. Duncan Mara, 1984, Technology Advisory Group, World Bank; all publications mentioned in this review out of print.

This summarizes the basic design considerations for building ventilated pit latrines out of a wide variety of materials. These latrines are claimed to have superior health benefits because they effectively control flies. They are relatively free of odors making them more easily acceptable and perhaps more regularly used than conventional pit latrines. The design also eliminates squat plate covers, which have been a problematical element of many other latrine designs. Examples are given from a half dozen countries. A central design feature of these latrines is a vent pipe which can be costly. Lower cost alternative vent pipes are described, along with construction details; these pipes are made of reeds, jute and wire mesh, or anthill soil, all coated with cement mortar.

Investigation has revealed the importance of sizing vent pipe diameter to match local wind conditions. (See **Ventilated Improved Pit Latrines: Vent Pipe Design Guidelines**, **Disk 13, File 17-410**, booklet, 16 pages, by Beverly Ryan and D. Duncan Mara, 1983, same source.) As proper vent pipe diameter is crucial to the success of this design, those wishing to do their own wind-ventilation measurements prior to launching large-scale programs should consult **Pit Latrine Ventilation: Field Investigation Methodology** (**Disk 13, File 17-407,** booklet, 16 pages, by the same authors, 1983, from the same source).

Manual on the Design, Construction and Maintenance of low-cost, Pour-Flush Waterfall Latrines in India, **Disk 13, File 17-406**, book, 109 pages, by AK Roy et. al., 1984,

Technology Advisory Group, World Bank, Washington, DC, USA, out of print. The search for an affordable urban sanitation alternative has led to the selection of waterfall double vault latrines as the subject of a large-scale UNDP. program in India. This manual describes the technical, legal and institutional requirements for this program in great detail.

Septic Tank Practices, **Disk 13, File 17-398** book, 75 pages, by Peter Warship, 1978, out of print, limited number of copies still available for $4.95 from WEA.

Here is an excellent reference on septic tanks, emphasizing the natural ability of the soil to purify and absorb "waste water." This volume has very good sections on biology and maintenance, although it lacks the concise working details and plans of WHO's **Excreta Disposal for Rural Areas and Small Communities**.

"Homesite treatment is cheaper, pollutes less, recycles more, slows or controls urban sprawl, has fewer health hazards and remains personal and intimate with the necessities of water, nutrients, and the lives of other creatures. Centralized sewage disposal, shielded by public authorities, has kept citizens unaware of sewage costs, inadequate treatment and disposal as well as their own natural responsibility for recycling their own wastes and keeping other plants and animals productive and healthy."

The Design of Small Bore Sewer Systems , **Disk 13, File 17-401**, book, 52 pages, by Richard Otis et. al., 1985, Technology Advisory Group, World Bank, Washington, DC, out of print.

This unusual option for urban sewer systems consists of a small-diameter pipe drawing off waste water only. All solids are caught in an "interceptor tank" at each house. The result is a system in which the costs of excavation, materials , pumping equipment, treatment, etc. are greatly reduced.

"Experience with the system is limited and mixed. Consequently, in spite of its obvious advantages it must be used judiciously and adopted only in situations where there is sufficient provision to ensure a strong organization for maintenance. This organization must also be able to exercise effective control over connections to the system. Special precautions should be taken to prevent illegal connections, since it is likely that interceptor tanks would not be installed in such connections, thereby introducing solids into a system which is not designed to handle solids. This could create serious operational problems."

Human Faeces, Urine, and Their Utilization, **Disk 13, File 17-394,** book, 53 pages, translated by the ENSIC Translation Committee, 1981, $5.00 postpaid from the Environmental Sanitation Information Center, Asian Institute of Technology, P.O. Box 2754, Bangkok, Thailand.

Human wastes are high in nitrogen and other nutrients and can be a valuable source of fertilizer. But, in their raw state, human faeces may pose health hazards and the nutrients may not be available to crops. The Vietnamese original for this book was written to encourage local farmers to make use of simple composting methods for human faeces and urine in order to produce valuable and safe fertilizers. The nutrient requirements for various crops and nutrient content of fertilizers are presented, followed by several methods for collection and composting of human wastes. Proper application of the final product to various crops is also discussed. Emphasis throughout is placed upon maintenance of sanitary standards and maximization of the fertilizer's nutrient value. Exclusive use of locally available materials is assumed. Highly recommended.

Aquaculture: A Component of Low Cost Sanitation Technology, World Bank Technical Paper Number 36, **Disk 13, File 17-411,** book, 45 pages, by Peter Edwards, 1985, $6.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170- 8619, USA.

In a number of countries, aquaculture ponds play a role in treating human waste. This volume describes the way this is done in China, India (Calcutta) and other countries. In outlining the feasibility of this technology for wider use, biological, public health, economic and sociological aspects are discussed.

The authors note that the expense of even a low-cost sanitation system is a large, often overwhelming burden to governments and households. However, human excreta recycling in aquaculture is already done by millions of people in Asia, and the economic benefits can outweigh the costs. The result can be "a stronger motivation for further investments in sanitation."

Natural Sewage Recycling Systems, **Disk 13, File 17-395**, report, 36 pages, by Maxwell Small, 1977, accession no. BNL 50630/LL, paper copies $15.00 domestic, $30.00 foreign; microfiche $8.00 domestic, $16.00 foreign; from NTIS.

"This paper reviews the work done at Brookhaven National Laboratory in the development of natural systems which produce potable water from sewage." A pond is constructed that is marsh at one end and open water at the other. Human wastes are pumped into this pond after passing through an aeration pond. The first pond adds oxygen to the sewage to reduce nitrogen levels and eliminate odors. "Conventional treatment plant hardware beyond aeration is not used ... and no sludge is generated."

The marsh/pond system of natural treatment is much less costly than traditional Western systems of sewage treatment. Human wastes could be brought to the system in pipes, buckets or tanks. The aeration pond requires a floating aerator pump with .3 hp of capacity for each 1000 gallons per day of sewage passing through it. A pump is also recommended to move the aerated human wastes to the second pond.

"Experiments with two prototype systems are described and performance data are presented in detail for the marsh/pond. Empirical interpretations of results achieved to date are suggested for use in the design of marsh/ponds as natural sewage recycling systems."

Plants and aquatic life can be harvested to provide food, fiber and energy. The marsh plants are of great importance and must be harvested regularly to prevent overcrowding.

Wastewater Irrigation in Developing Countries: Health Effects and Technical Solutions, World Bank Technical Paper No. 51, **Disk 13, File 17-413,** book, 325 pages by Hillel I. Shuval et. al., 1986, $22.95 from World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

"The reuse of domestic wastewater and the recycling of other human wastes in agriculture can produce significant economic benefits and help defray the large costs of municipal waste management ....

"In its modern form, the reuse of wastewater effluents for irrigation of crops offers attractive benefits, such as increasing water supplies for productive agricultural use, adding valuable fertilizers and micronutrients to maintain soil fertility, and reducing pollution of surface water sources."

After reviewing the practices of wastewater irrigation around the world, the authors evaluate the associated health risks, and propose economical methods for minimizing these risks.

"In particular, multicell stabilization ponds with 20 days' detention time effectively remove bacterial, viral, and helminth pathogens in a low-cost, robust, easy-to-operate system that is especially suitable to developing countries."

The most economically attractive locations for wastewater irrigation are arid and semi-arid regions. World maps with an "aridity index" are provided, allowing the reader to roughly determine whether this technology may be worth considering locally. Most of California, for example, is dry enough to make wastewater reuse attractive. There are in fact over 200 such projects in California.

I. Water Refuse and Solid Waste Management

Residential Water Re-Use, California Water Resources Report No. 46, **Disk 13, File 18-401** book, 533 pages, by Murray Milne, Water Resources Center, University of California, Davis, 1979, out of print.

This is the best book available on the reuse of greywater (household waste water, not contaminated with human excreta). A good illustrated summary of proven and experimental household greywater reuse systems is followed by an explanation of the necessary components. The major recommended use for greywater is in garden and tree crop irrigation; a lengthy section on this topic summarizes the technical considerations involved. A limited amount of information is offered on developing sources of fresh groundwater and surface water for household use.

"The conclusion of this study is that residential on-site water reuse systems are already technically feasible and environmentally sound, and are becoming more economically attractive everyday, due primarily to the rapidly increasing cost of energy required for pumping and treatment by centralized water and sewage systems. The objective of this book is to help homeowners, builders, developers, architects, planners and lawmakers understand the design and installation of small on-site residential water reuse systems."

A directory of manufacturers of special equipment and an extensive annotated bibliography on greywater are also included. Though developed for conditions in the state of California, this book has much that will be of interest anywhere in the world.

Management of Solid Wastes in Developing Countries, **Disk 13, File 18-400**, book, 242 pages, by Frank Flintoff, 1976, stock no. 1560001 from World Health Organization, New Delhi, India.

"Wherever people live, wastes, both liquid and solid, are produced. While the disposal of liquid wastes more often receives priority attention, the management of solid wastes has generally been a neglected field. The aim in developing countries must not be to mimic the technology of the industrialized countries, but rather to employ the technology appropriate to their own situations, while still meeting the basic needs of public health."

This book covers methods for disposal and recycling of solid wastes (both household and commercial). It is intended "to provide a reference source for engineers, municipal officers, administrators, and other interested persons, and to fill a need for a training manual for technicians in a field of universal and growing importance." Major topic areas include economic and other aspects of refuse collection and storage, sanitary landfills, and composting of urban wastes.

The coverage of composting programs is quite comprehensive. "Transport between the compost plant and the farm is an important cost element; in most situations this cost limits the marketing range to about 25 kms. diameter and if the plant is in a very large city, much of that circle will be occupied by urban areas; therefore, the larger the city the smaller the potential market for compost. The larger the city, however, the greater the quantities of waste. Thus composting as a policy suffers from the paradox that the potential market is in inverse ratio to potential wastes production .... The most successful composting plants have been those which serve small towns in agricultural areas."

Though this book is primarily devoted to large-scale solid waste operations, there is much that would be useful in small-scale projects.

Recycling from Municipal Refuse: A State-of-the-Art Review and Annotated Bibliography, World Bank Technical Paper No. 30, **Disk 13, File 18-402**, book, 214 pages, by Sandra Cointreau et. al., 1984, $12.95 from World Bank Publications, Box 7247-8619, Philadelphia PA 19170-8619, USA.

A 24-page overview which provides many examples of municipal recycling around the world, along with a discussion of constraints and incentives. The annotated bibliography includes some 200 published items covering topics that vary from plastics recycling and de-inking of paper in Germany to municipal systems involving scavengers in Cairo, Egypt and Cali, Columbia.

ADDITIONAL REFERENCES ON WATER SUPPLY AND SANITATION

The use of human wastes in biogas plants is described in **Compost, Fertilizer, and Biogas Production from Human and Farm Wastes in the People's Republic of Chin**a; see ENERGY: BIOGAS.

Simple Working Models of Historical Machines includes drawings of a variety of machines for pumping and raising water, including the Archimedes screw, chain pump, suction pump, and diaphragm pump, see GENERAL REFERENCE.