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FINAL REPORT

A GUIDE TO TECHNOLOGY SELECTION AND PLANNING FOR VILLAGE WATER SUPPLIES UTILISING GROUNDWATER AND SPRING WATER SOURCES

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CERTIFIED AN OFFICIAL FINAL REPORT

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for NATIONAL ENERGY COUNCIL DATE

A GUIDE TO TECHNOLOGY SELECTION AND PLANNING FOR VILLAGE WATER SUPPLIES UTILISING GROUND AND SPRING WATER SOURCES

Keith Wiseman MSc (UCT), BSc Honours (Wales).

FOREWORD

This guide to planning and technology selection for village water supplies is a result of an earlier study undertaken by Mr Keith Wiseman MSc and Dr Anton Eberhard of the Energy Research Institute of the University of Cape Town. That study, entitled "A Technical, Economic and Social Analysis of Alternative Water Lifting Technologies for Underdeveloped Rural Areas" (Report No Gen 121, CSIR Pretoria) included a review of village water supply schemes in underdeveloped areas throughout the world, an analysis of commonly used, potential and experimental water lifting technologies, and an economic assessment of the cost of pumped water for a variety of heads, flow rates and other parameters such as lifetime and maintenance costs.

Further, the results of that study, which form the foundations of this guide, are based on field studies of villge water schemes in KwaZulu and Transkei. Whilst these areas represent only a part of the underdeveloped rural population in South Africa, the principles which were found to lead to successful, sustainable community water supplies are appropriate to all underdeveloped communities in this country. Their application can lead to a higher cost-effectiveness for village water supply schemes than exists at present. Similarly, although only groundwater and spring water sources are addressed in this Guide, many of the principles for successfull water schemes can be applied to rainwater collection, surface water sources and other potentially usefull water sources.

Finally, I would like to thank Dr Anton Eberhard for his support and patience throughout this project, and the CSIR for supporting research into the critical problems existing in underdeveloped areas.

Keith Wiseman MSc (UCT), BSc Honours (Wales).

GUIDE TO TECHNOLOGY SELECTION AND PLANNING

FOR VILLAGE WATER SUPPLIES

List of Boxes:

List of Figures:

List of Tables

CHAPTER ONE

INTRODUCTION

1.1 The Problem

Providing a clean, potable supply of water is a critical problem in remote or underdeveloped rural areas. Water is needed for drinking, cooking, washing and bathing, but is often only available from traditional sources such as springs, rivers or ponds. These water sources are in most cases contaminated by livestock and cattle, and situated far from homesteads. During dry periods they often dwindle or dry up completely.

The collection of water is a strenuous and time-consuming task for rural women, who may spend up to three hours per day fetching water for use in the household. In addition, rural communities suffer from many water borne diseases, including cholera and typhoid. There is also a high incidence of gastro-enteritus caused by insufficient water for general hygiene and the fecal contamination of water.

A large proportion of village water supply schemes have been found to fail soon after they are implemented. This is often due to the incorrect choice of water source, or as a result of frequent breakdowns and slow repairs of the water supply technology.

The problems associated with water supply in rural areas can be placed into four general categories:

* the **QUALITY** of water
* the **QUANTITY** of water
* the **DISTANCE** to water, and
* the **RELIABILITY** of water supplies.

1.2 Purpose of this Guide

The purpose of this guide is to aid water supply planners and decision makers to provide village water supplies that:

* are adequate to meet domestic water needs,
* provide good quality water,
* provide water within reach of residents' homes,
* are reliable and sustainable.

The guide is intended for use by any person who is responsible for planning, implementing or providing a maintenance service for village water supplies. This includes central and regional government departments, responsible for implementing water supply schemes as part of national programme, and those representing independent local and international aid and development organisations. The guide will also be useful to local representatives planning to improve their own water supplies, as it provides an overview of both the costs and benefits of improved water supplies, together with the more technical aspects of water and health, water use, and the commonly used water supply technologies.

Although the provision of water for agricultural use is not directly addressed in this guide, many of the concepts and technologies mentioned here would be useful for planning such schemes.

1.3 Layout of the Guide

In Chapter 1 the major problems associated with domestic water supply in underdeveloped rural areas are briefly reviewed. The purpose of the guide is defined, including its intended audience. An introductory diagram shows how this guide may be used by water supply planners.

In Chapter 2, the sequence of decisions and considerations that must be taken into account are described. This begins with obtaining support for the scheme, and evaluating the choices of technology, water source and supply level of service. The role of the benefitting community in this first step to sustainable water supply schemes is discussed in section 2.2. Various options for the maintenance of completed schemes are then described in section 2.3, and the usefulness of post project evaluation and monitoring in section 2.4.

In Chapter 3 the "social" factors of community involvement and village level responsibilities and organisation are discussed. A broad account of these issues is given, since the detailed aspects are addressed where appropriate throughout the guide.

In Chapter 4 a review of the technical choices associated with water for health (section 4.1), water source selection (section 4.2), and water use and level of service (section 4.3) is presented. Section 4.4 then contains a review of commonly used village water supply technologies - spring protection, hand pumps and foot pumps, wind pumps, diesel pumps and solar pumps. This includes the advantages and disadvantages of each, the likely cost of a complete scheme and the normal servicing and maintenance requirements of each technology. A flow diagram to aid technology selection is presented at the end of section 4.4.

Chapter 5, Economic Choices, contains a summary of the costs and benefits associated with village water supply schemes (section 5.1), and a comparative analysis of the cost of pumped water of the commonly used technologies (section 5.2).

A list of selected references, available in South Africa, is given at the end of Chapter 5.

Finally, the Appendices include the specifications of various water supply technologies available in Southern Africa.

1.4 How to Use this Guide

The guide is divided into four parts, each addressing one aspect of providing domestic water supplies in remote villages.

The overall planning framework and conceptual strategies for village water supplies including servicing and maintenance, are addressed in Chapter 2.

The social and community considerations important to the success of village water supply schemes are described in Chapter 3.

The technical aspects of water quality, water sources, water use and choice of technologies and scheme implementations are addressed in Chapter 4.

The financial effects of technology choice and maintenance options are shown in Chapter 5.

A summary of the village water supply planning process is shown on the next page. From this can be seen the information and data needed at each stage in the planning process together with a reference to the relevant part of this guide.

TABLE ONE

THE VILLAGE WATER SUPPLY PLANNING PROCESS

STAGE	PEOPLE INVOLVED	ACTIVITIES	RELEVANT PART OF THIS GUIDE
1) PROJECT PREPARATION	Central planner + extension services + community	Identify water needs.	4.3
		Assess available water sources in village.	4.1, 4.2
		Determine community contribution - initial and ongoing to the project.	Chapter 3
		Inform community of costs, benefits and constraints.	5.1, 4.1
2) TECHNOLOGY SELECTION*	Extension services + community	Determine technological options according to physical, financial and institutional constraints.	Chapter 4 +2.3
		Choose most cost effective technology.	Chapter 5
3) SERVICING AND MAINTENANCE	Central planner + regional services + community	Make provision for preventative servicing.	Chapter 2
		Choose most appropriate maintenance strategy.	2.3
4) EVALUATION AND MONITORING	Central planner + extension services + community	Ensure a reliable communication link exists.	3.3
		Use regular monitoring to maintain or improve scheme performance.	2.4
		Evaluate the operational scheme in terms of its original objectives and strategy.	2.4

CHAPTER TWO

PLANNING VILLAGE WATER SUPPLY SCHEMES

2.1 The Chain of Decisions

The successful planning, implementation and long term operation of a village water supply scheme requires that the responsible decision maker address technical, economic and social considerations. Technical choices are made when choosing the water source and supply technology; economic considerations strongly influence the technical choices, and social considerations must be taken into account if the completed scheme is to fulfill for users the criteria of quality, quantity, distance and reliability. Each of these considerations are both critical to the long term success of the scheme and, as will be seen throughout this guide, strongly interdependent with the other two.

The chain of decisions discussed in this section does not only refer to the decisions taken by the water supply planner. This is because the most desirable scheme is one in which the community undertakes the major tasks of planning, technology selection and maintenance. This guide, however, addresses the planning process from the perspective of a central planner, since this is the most common approach of homeland and regional administrators in South Africa.

Nevertheless, the community context of such schemes is critical to the planning process. As will be shown in the next section, community involvement in technology selection, water point siting, maintenance and finance is essential for long term success, and can have the benefit of reduced costs to the administrative agency. Water supply schemes that are provided as a free service from the government without consulting or involving the community have been found to be inappropriately located, poorly maintained, and often rejected by the users.

2.2 Project Preparation and Approval

The water supply planning process begins with the decision by a planner, whether a local resident or government representative, to improve the water supply of a chosen community. The government planner will take other considerations into account in his/her decision besides the existing water sources in a village. These may include the reduction of travelling costs by allocating funds to clusters of villages within a particular region. The success or failure of previous schemes in an area may also be taken into account. In effect the selection of villages in this way is a political process, involving the allocation of scarce financial and institutional resources, and is outside the scope of this guide.

Once a village has been identified as needy and chosen for water supply improvement, the process of choosing the water supply technology and obtaining local support for the scheme may begin. This process will involve the extension or field officer of the agency administering the water supply scheme. The role of the extension officer in this early phase is to clearly identify the water needs of the community, provide a reliable communication link between the village and the administering agency, and help the villagers to establish their own institutional framework for managing the water supply scheme.

This process usually involves a number of village meetings attended by the extension officer, the villagers and village leaders. At these meetings the extension officer should:

* explain the benefits of an improved water supply,

* obtain popular support for the idea of installing an improved water supply,

* describe the financial and institutional limitations of the administering agency,

* help the community to elect a water committee, if one does not already exist, and clearly establish the role and responsibilities of the committee,

* establish an operational link between the water committee and administrative agency, and

- establish what resources the community is prepared to contribute, initially and over the scheme's lifetime.

By assessing the available financial and institutional resources within the village together with those available from the administrative agency, the most appropriate water supply technology and level of service for the water scheme can be identified. As will be seen in section 4.3, this can vary from a spring protection scheme with one standpipe, to multiple handpump installations, or to a motorised pump and multiple standpipes. The chosen scheme must be sustainable within the constraints of the available financial, technological and institutional resources.

Community involvement: this stage of the planning process should involve the community in:

- assessing water needs,

- choice of the technology and site and number of water points, and

- determining what financial contribution the community is prepared to give. This may include a contribution to the capital cost of the scheme and/or regular contributions for maintenance.

2.3 Servicing and Maintenance

The degree to which any community water supply is able to provide an efficient and reliable supply of water is determined by the effectiveness of the maintenance system available to it. Although the durability of the pump design and components is an important factor, many national and international studies of water supply schemes, including studies in South Africa, have shown that maintenance difficulties arise more from institutional or financial inadequacies than from technical difficulties with the pumps themselves.

Box 1 overleaf shows that, by defining reliability as the probability that a pump is working, a pump which breaks down once every 8 months and takes 1 week to repair is more reliable than one which breaks down once every 18 months and takes 2 months to repair. An example of this would be a simple handpump which is repaired quickly by a local mechanic, compared to a more complex "no maintenance" design which requires a mobile team of trained mechanics for repair.

2.3.1 Servicing

The reliability of most water supply technologies can be improved by the regular servicing of moving parts. Although regular preventative servicing of water supply technologies does not take place in most underdeveloped areas of South Africa, it can result in considerable cost savings for corrective maintenance. For example, bearing failure on handpumps and gearbox failure on windpumps are both known to cause frequent failure of village water supply systems. In both cases gradual wear leads to poor pump performance and eventual breakdown. By applying preventative servicing, in which a pump caretaker oils moving parts and tightens loose bolts, the high costs of pumphead repair and gearbox replacement can be significantly reduced.

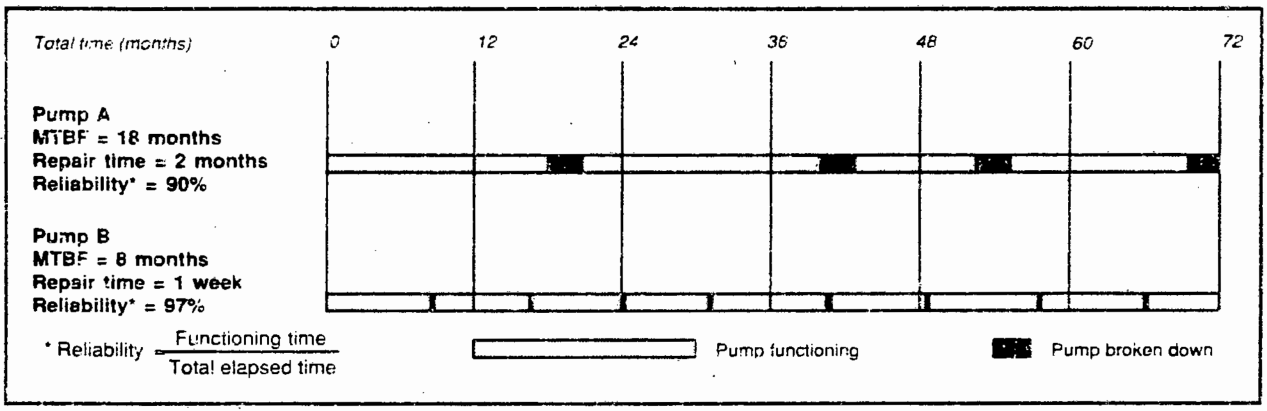
BOX 1

WHAT IS 'RELIABILITY'?

Reliability, as applied to a water supply, is a measure of how often water is available compared to how often it is not. The conventional interpretation of reliability applied by engineers is "Mean Time Before Failure". A more satisfactory interpretation for the case of water supplies, however, is:

> "the probability that the pump is in operating condition on any one day, calculated as the sum of the operating time before failure divided by the total time".

The use of the term "probability" has important consequences for comparing institutional maintenance procedures. The diagram below illustrates operational and down time periods for two pumps having different maintenance systems.



for pump A Reliability = 64/72 = 90%

for pump B Reliability = 70/72 = 97%

Hence pump B is more reliable than pump A.

Acknowledgement: Arlosoroff *et al* 1987.

The VLOM Concept: The idea of village level servicing and maintenance of water supply schemes has gained popularity internationally as a result of the United Nations' International Drinking Water Supply and Sanitation Decade (1980 - 1990).

A major study aimed at understanding the problems of providing water in underdeveloped areas was the joint UNDP/World Bank "Inter-regional Project for Laboratory and Field Testing and Technological Development of Handpumps for Community Water Supply". An early conclusion of that study, which by 1986 had monitored the performance of some 2700 handpumps in 17 countries, was that:

> *"strong involvement of the user community in maintenance was essential for successful (water supply) projects".*

The term VLOM - Village Level Operation and Maintenance - was coined to emphasize to manufacturers and users that centralised maintenance systems are unsuitable for village water supply schemes.

2.3.2 Maintenance

In this section a spectrum of maintenance procedures is described. These vary from the full responsibility of a central agency, as is presently the case with most government administered water supply schemes in South Africa, to the full responsibility for maintenance resting with the user community.

System 1) Full Community Responsibility

In this system an elected water committee collects money and organises all aspects of pump maintenance and repair. Such a system requires strong community leadership and a high organisational capacity. Regular collections of household contributions to maintenance costs are necessary and a skilled mechanic with tools and a supply of spare parts must be available.

The establishment of this infrastructure will usually require an initial input from an external agency, such as a public authority, in the form of training for simple pump repairs and financial management. Regular monitoring will also be necessary to ensure that the system is operating and to provide backup services if they are needed.

The benefits of this system include increased levels of education and organisation with a strong and efficient local infrastructure. A successful community maintenance system will also reduce the long term responsibilities of central institutions to a minimum, greatly reducing capital and maintenance costs.

This type of system has been tried in South Africa, but with mixed results. Two examples are briefly described here:

Example 1) The KwaZulu Water Development Fund (WDF)

The WDF provides boreholes equipped with handpumps to needy villages in KwaZulu. In order to obtain a pump the community is encouraged to elect a water committee, who then collect a contribution to the capital cost of the scheme. Once completed the borehole installation is handed over to the community and they are given full responsibility for maintenance. The water committee is advised to raise money for repair or replacement of the handpump.

A survey of such schemes in 1986, however, found no evidence of successful maintenance by any of the communities visited. In many cases the existence of water committees was in doubt, many pumps were broken or operating poorly and household contributions had not been collected.

The failure of this system can be attributed to an insufficient training and organisational input by the WDF. Other contributory factors may include poor community leadership, political differences within communities, inadequate extension services, and the poor siting of boreholes, leading to inadequate borehole yields, queues and a return to traditional surface sources of water.

Example 2) The Valley Trust

The Valley Trust operates in the Valley of a Thousand Hills near Durban. Its philosophy is to act only in an advisory role in water supply and sanitation schemes. Communities are responsible for planning, construction and maintenance of their own projects, with the Trust providing technical advise on spring protection and maintenance techniques. A revolving loan fund is used to help villages purchase raw materials that are necessary.

The success of the Valley Trust projects is reflected in the fact that requests for assistance with spring protection are received weekly. Also, villages with protected springs have begun to collect money for further improvement of their water supplies.

System 2) Partial Community Responsibility

In this system the user community is responsible for servicing and "first line" maintenance of the water supply, and a central or regional agency is responsible for more complex repairs. The community may also be responsible for financing repairs, through the collection of regular households contributions by an elected water committee. The division of responsibilities is established during the planning and design of the project by discussions between the community and administering agency. As in the case of full community responsibility, a training and advisory input from the external agency will usually be required for the establishment of this system.

Although few examples of partial community responsibility presently exist in South Africa, it has been successfully applied to shallow well handpump schemes in Malawi. In those schemes a village caretaker is appointed for each pump and is responsible for servicing and simple maintenance of the pump head. Breakdowns of the pumps are reported to a government trained area mechanic. The mechanic is equipped with a bicycle or motorbike and tools. A locally manufactured pump is used in order to increase the availability of spare parts.

In the Malawi system the community does not pay for repairs or spare parts, but household contributions are collected to pay the pump caretaker.

System 3) Centralised Maintenance

This system, which is widely used by government agencies throughout South Africa, consists of a central administration managing mobile regional maintenance teams. The teams report to a central headquarters which manages the overall budget and purchasing of spare parts. Each team is equipped with a vehicle, one or more skilled technicians, tools (which may include a rig for lifting below ground components) and a number of labourers.

Recent studies of water supplies in South Africa maintained by central teams have shown that this system is inadequate to repair pumps quickly, expensive, and contributes significantly to the unreliability of many schemes. The UNDP/World Bank study referred to earlier, which monitored water supply schemes in 17 different countries, also concluded that:

> *"Centralised maintenance, which depends on a mobile team of skilled mechanics travelling to repair breakdowns in motor vehicles, has proved to be expensive and unreliable on all types of water supplies".*

(Arlosoroff *et al*; 1987)

Example

Village water schemes administered by the Transkei Department of Agriculture and Forestry, TDAF, are maintained by mobile teams managed from the administrative capital of Umtata. Each scheme consists of a windmill which lifts water to a reservoir situated at a high point in the village. From there water is distributed by gravity to standpipes sited throughout the village. The schemes are planned, implemented and maintained with no community involvement.

The high capital cost of these schemes is not reflected in benefits to communities due to the high incidence of windmill breakdowns and slow repairs. Up to 1986, 1300 such schemes had been implemented throughout Transkei. It was estimated by the Director of the TDAF in April 1986 that 30 to 40% of these were not in working order.

On average the first breakdown of a windmill scheme was estimated to occur three months after installation. The average time taken for repair was reported to be about three months. The main causes of delays were found to be poor communication between villages and the centrally administered maintenance services, and delays in obtaining spare parts, an insufficient number of maintenance teams due to a shortage of skilled persons, and the high cost of the centralised maintenance system.

Further detailed information on community involvement and reponsibility in village water supply schemes (based on practical first hand experience) may be obtained from:

The Director,
Transkei Appropriate Technology Unit,
Private Bag X5029,
UMTATA

Telephone Umtata 2741.

2.4 Evaluation and Monitoring

The final stage in the village water supply planning process is the evaluation of the success of the completed scheme and the monitoring of its performance and the performance of maintenance and backup systems, over time. Although the information and insight gained during this phase of the planning process is invaluable for the successful planning, implementation and maintenance of future schemes, it is often a neglected aspect of water supply planning.

Purpose of Evaluation

There are two main purposes for post-project evaluation:

1) To provide feedback on the success of the project itself. This will enable an assessment to be made of the success of the project in terms of the four criteria listed in section 1.1:

2) To provide feedback to the planning process.

The evaluation should then ask:

- * Is the quality of water as expected?
- * Has the distance to water been reduced for some or all of the villagers?
- * Has the quantity of water available to villagers been increased as a result of the scheme?
- * How reliable is the water supply?

In effect this evaluation will take the form of a comparison of the initial objectives of the scheme, the predicted performance and the actual performance of the water supply.

Comparing these with the schemes objectives and the planning policies used will highlight strengths and inadequacies in the institutional and administrative frameworks.

A critical and thorough evaluation of selected projects will also provide feedback for planning and design on such aspects as:

* what changes in operation and maintenance procedures might improve the level of service,

* the appropriateness of the water supply strategy in terms of resource allocation, choice of technology and nature of extension services in terms of the objectives, and

* areas where complementary inputs to the water supply schemes, such as health education, technical or agricultural training, could improve the efficiency, effectiveness and degree of success of water supply schemes.

Regular monitoring, on the other hand, will provide the information necessary to maintain or improve project performance as a routine activity of the water supply agency administering the scheme.

CHAPTER THREE

COMMUNITY INVOLVEMENT IN WATER SUPPLY PLANNING

It can be seen from the previous section of this Guide that the consideration and inclusion of the benefitting community throughout the planning process is a requirement for successful water supply schemes. This chapter contains a more generalised account of community participation, since the detailed aspects are addressed where appropriate throughout this guide.

3.1 Why involve the community?

The provision of domestic water supplies in developed areas rarely if ever, involves the user community. Water supplies are provided by a local authority or municipality, who in turn collect revenue in the form of rates or levies to pay for the supply. In some areas, users are charged according to the amount of water consumed.

Such a system is both impractical and improbable in a remote, underdeveloped area. It is impractical since the necessary institutional and administrative resources are not available, and the high cost of construction cannot be recovered from the user community. It is improbable since, if a functioning, well maintained household water supply existed, then the area served is unlikely to be described as underdeveloped!

The inclusion of the community in the planning process then serves four main purposes:

* it allows the most efficient type of water supply to be implemented, such that the ratio of community benefit to capital and recurrent costs is maximised,

* it reduces the demands and hence costs borne by the administrative agency, by creating a village level infrastructure for servicing and maintenance,

* it improves the effectiveness of evaluation and monitoring systems, by creating a channel for communication between the community and the water supply agency, and

* it avoids the problems of malicious damage, neglect and rejection of the water supply often associated with the provision of a scheme as a free service from a remote government.

3.2 Women and Water

Rural women have traditionally been responsible for collecting water. They are also responsible for a multitude of other household chores, including collecting firewood, tending vegetable gardens, cooking, washing and caring for the men and children.

Despite the critical role of women in providing water, it is often the men who are consulted when decisions regarding the siting of households and water points are taken. This results in poorly located water points, reducing considerably the benefits of water supply schemes.

Recent experience in many underdeveloped areas of Southern Africa has also shown that the involvement of the women in a village can facilitate a higher degree of willingness and cooperation in planning and maintaining village water supplies. In many areas, concerns that training women in maintenance skills would conflict with their traditional role in society have proved to be unfounded. Instead, women pump-caretakers and water committees have proved to be enthusiastic and reliable, probably as a result of their traditional role of providing water.

3.3 Responsibility and Resources

Community participation in village water supply schemes must not be limited to providing free labour. Such a policy fails to address the critical issues of creating an institutional capacity in the village which is capable of managing a water supply scheme and informing villagers of the benefit of improved water supplies.

An assessment of the institutional resources existing in a village must be included in the planning of a water supply scheme. Such resources may include self-help groups, garden committees or cooperatives and a water committee. An elected water committee can act as a focus for water supply development in a village. For this to occur, however, the committee must have a clearly defined role and responsibilities. If it does not, then the committee is likely to become inactive soon after the new water supply is installed.

The responsibilities of the committee may include calling on external maintenance services when required, collecting household contributions towards the initial cost and for spare parts and maintenance, improving health education in the village, and keeping water points in a clean and tidy state.

The financial resources of a rural community are not extensive, but experience in many underdeveloped areas has shown that some financial contribution to a water supply scheme is usually desirable. This must be made in conjunction with community involvement in planning the level of service and siting of water points, in order that the community understands the limitations of the scheme and is aware of its benefits. A common strategy in this respect is to collect household contributions to the capital cost of the scheme before construction commences. Regular household contributions may then be collected towards servicing, maintenance and paying a "retainer fee" to the pump caretaker.

CHAPTER FOUR

TECHNICAL CHOICES

4.1 Water for Health

Water supply schemes can have considerable health benefits for rural communities. In particular the high incidence of infant mortality from diarrhoea associated with infected water can be reduced. Improvements in the quality and quantity of water available to villagers can also reduce the incidence of diseases associated with infected water and those associated with inadequate water for general hygiene.

In order to maximise health benefits, however, improvements in water supplies must be accompanied by similar improvements in waste disposal, sanitation, and health education. This is because the severe health problems existing in many rural communities are related not only to poor water supplies, but also to improper methods of fecal waste disposal, poor personal and cooking hygiene practices (often related to inadequate water supplies for washing) and poor nutritional status.

The interrelationship of health, hygiene, water, education and nutrition forms the basis of *Integrated Water Supply Planning.* In this approach water supply schemes are implemented in conjunction with complementary inputs such as education and awareness programs, afforestation programs, the construction of improved pit latrines and the establishment of irrigation systems. By integrating water supply schemes with other such inputs, increased awareness and acceptance of the schemes as well as other benefits associated with economies of scale can be achieved.

4.2 Water Source Selection

The main sources of water occurring in rural areas are:

- Rainwater: This may be collected and used in the household.
- Springs: Natural springs occur in many rural areas. They have traditionally been a source of water and can with improvement provide reliable supplies of good quality water at low cost.
- Rivers: Also a traditional source of water, rivers are commonly a source of domestic and agricultural water requirements. However, many rivers contain water of very poor quality.
- Groundwater: Groundwater sources are exploited in many developed as well as underdeveloped areas for agricultural and domestic water supplies.

The criteria for choosing a water source should include an assessment of its capacity to meet predicted water requirements, and its reliability. Whilst seemingly obvious, these two criteria are often overlooked or given inadequate attention, resulting in water supplies that

- fail to meet the communities water needs, and
- run out of water during dry periods or times of peak water demand.

Methods for anticipating the water use of rural communities are discussed in section 4.3.

The advantages, disadvantages and criteria for use of springs and groundwater are described below. Rainwater collection and the bio-chemical treatment of river water are beyond the scope of this guide.

Spring Water Sources:

Spring water is the result of the seepage of rainwater into underground aquifers. The aquifer may slope in a particular direction and intersect the side of a hill or mountain, at which point a spring will occur. This point is called the "eye" of the spring.

The use of unprotected springs as sources of water for household use has a number of problems associated with it:

- The water is often contaminated by fecal material. This is caused by livestock or humans urinating or defecating within the rainwater catchment areas of the spring.
- The springwater is collected by scooping it out of a muddy pool or stream, causing further contamination.
- Some springs dry up or dwindle during dry periods.
- Springs are often located far from homesteads.

A popular first step for many water supply agencies, however, is to protect and improve spring water sources. This is because it is technologically simple, requiring no water lifting or pumping, and can provide increased amounts of good quality water.

The techniques used for spring protection are well standardised within the development organisations that use them in South Africa. Several criteria for selection are commonly applied to a spring before it is selected:

i) It must be a perennial water source, i.e flow all year round. The Transkei Appropriate Technology Unit recommends that it has a flow rate of at least 3 to 5 litres per minute during the dry season.

ii) The eye of the spring should be above the village to be served. Unfortunately, this criteria cannot be applied in many areas where villages are located at the top of mountains or hills.

iii) The spring should preferably be located within 500 metres of the village centre.

iv) The eye of the spring should be situated such that it is possible for water to flow into a reservoir tank under gravity.

v) The eye should be situated such that it can be sealed and protected from surface run-off, which could otherwise contaminate the spring water.

Having identified a suitable spring, its catchment is fenced to prevent contamination, the eye of the spring boxed and water piped under gravity to a ferro-cement reservoir. This procedure is described fully in section 4.4.

Spring protection has a high potential for village water supplies in underdeveloped areas. For example, it has been estimated that up to 60% of Transkei's rural water requirements could be met by developing spring water sources. It involves a simple technology with low construction and maintenance costs, and facilitates a high level of community involvement and responsibility.

Groundwater

Many areas in South Africa do not have surface or spring water sources that are suitable for protection or development as described above. This may be due to unsuitable topography or insufficient annual rainfall. In some cases the surface water potential has been reduced as a result of land mismanagement, overcrowding or overgrazing.

In such cases one solution is to utilise water from underground sources. These consist of rain water that has infiltrated the underlying rock strata.

Compared with surface and spring water sources, groundwater can have two important advantages:

* the water may be free from fecal contamination, and

* groundwater storage can provide a reliable supply of water all year round.

Unfortunately, many village water supply schemes utilising groundwater sources have been unsuccessful due to:

* poor siting of boreholes leading to inadequate yields of water,

* frequent breakdowns of borehole pumps,

- low water tables during dry periods,
- a greater rate of extraction that recharge of the aquifer,
- contamination of groundwater by poorly sited or overflowing pit latrines,
- reduction of the groundwater storage capacity due to overgrazing and land mismanagement, and
- naturally occurring salts and minerals making the borehole water unpopular with villagers, who then continue to use traditional water sources.

In addition, the cost of borehole drilling in remote areas with poor access is high, on to which must then be added the capital, installation and maintenance costs of a suitable water lifting technology.

Through the careful assessment of the groundwater resource, siting of boreholes and choice of water lifting technology, boreholes can provide a high level of water supply. Assessment of the groundwater resource as part of planning a village water supply scheme should include:

- a survey of local hydro-geological condition to locate water bearing rock strata,
- an assessment of the area and depth of water bearing rock to determine its capacity (reliable yield),
- suitable tests to determine if the bacteriological and mineral contents of the water are acceptable for domestic water supply,
- pumping tests to determine the pumping water level (which determines the pump lift or head required for regular pumping), and
- monitoring to determine the recharge rate of the aquifer.

In general, the geological conditions existing in South Africa are not ideal for the exploitation of groundwater sources. Underlying rock strata are often impermeable and the recharge rate of aquifers is slow. The use of borehole water sources without a proper assessment of local hydrogeological conditions has lead to many failed water supply schemes. For example, recent studies in KwaZulu found that 50% of handpump installations visited had inadequate borehole yields. This causes the pump to dry up during busy periods, such as the early morning and late evening. As a result long queues develop at the pump, water collection times increase and villagers resort to other unimproved water sources.

In Box 2 the various types of aquifers are described, and the effect of regular pumping on the water table, pump lift and output are shown.

BOX 2

GROUNDWATER: A MISUNDERSTOOD RESOURCE

Groundwater is a subsystem of the earth's hydrological cycle. Because it is not a visible component of this cycle it is often misunderstood, resulting in many unsuccessful and inappropriate attempts to exploit it.

For water to collect underground, there must be an area of land (called an intake or recharge area) into which precipitation can infiltrate and refill the storage space within the below ground rocks and soils. Hence any unit of land has its own specific hydrological characteristics which are dependent on the local topography, geology and soils.

Of primary importance in investigating the groundwater resources of a site is the existence of aquifers. There are three types of aquifers, shown schematically in Fig 1.

1. Unconfined aquifers occur in permeable rock overlying impermeable rock. These aquifers are charged by seepage from the land area directly above them.

2. Confined aquifers are contained between layers of impermeable rock above and below them. The recharge areas of a confined aquifer may be some distance away from the aquifer itself.

3. Perched aquifers develop above impermeable rock. They are usually small and may develop seasonally.

Two main problems occur when boreholes are incorrectly sited or water is extracted too quickly:

Firstly, since aquifers are charged directly by seepage they may be contaminated by unsuitable activities in the recharge area. Groundwater may be contaminated by septic tanks, rubbish tips and the careless disposal of household waste. The siting of these in relation to boreholes is very important for domestic water supplies. A typical example is shown in Fig 2.

Secondly, pumping water from a borehole lowers the water table in the vicinity of the borehole. The resulting drop in the water table is called a cone of depression. This effect is illustrated in Fig 3. The greater the rate of pumping, the steeper the slope of the cone of depression, so that the depth of water in the borehole increases. The cone of depression also depends on the rate of recharge of the borehole. If water is extracted at a rate greater than the rate of recharge, the cone of depression will drop below the pump and the borehole will dry up.

FIGURE ONE

SCHEMATIC ILLUSTRATION OF THE THREE TYPES OF AQUIFERS

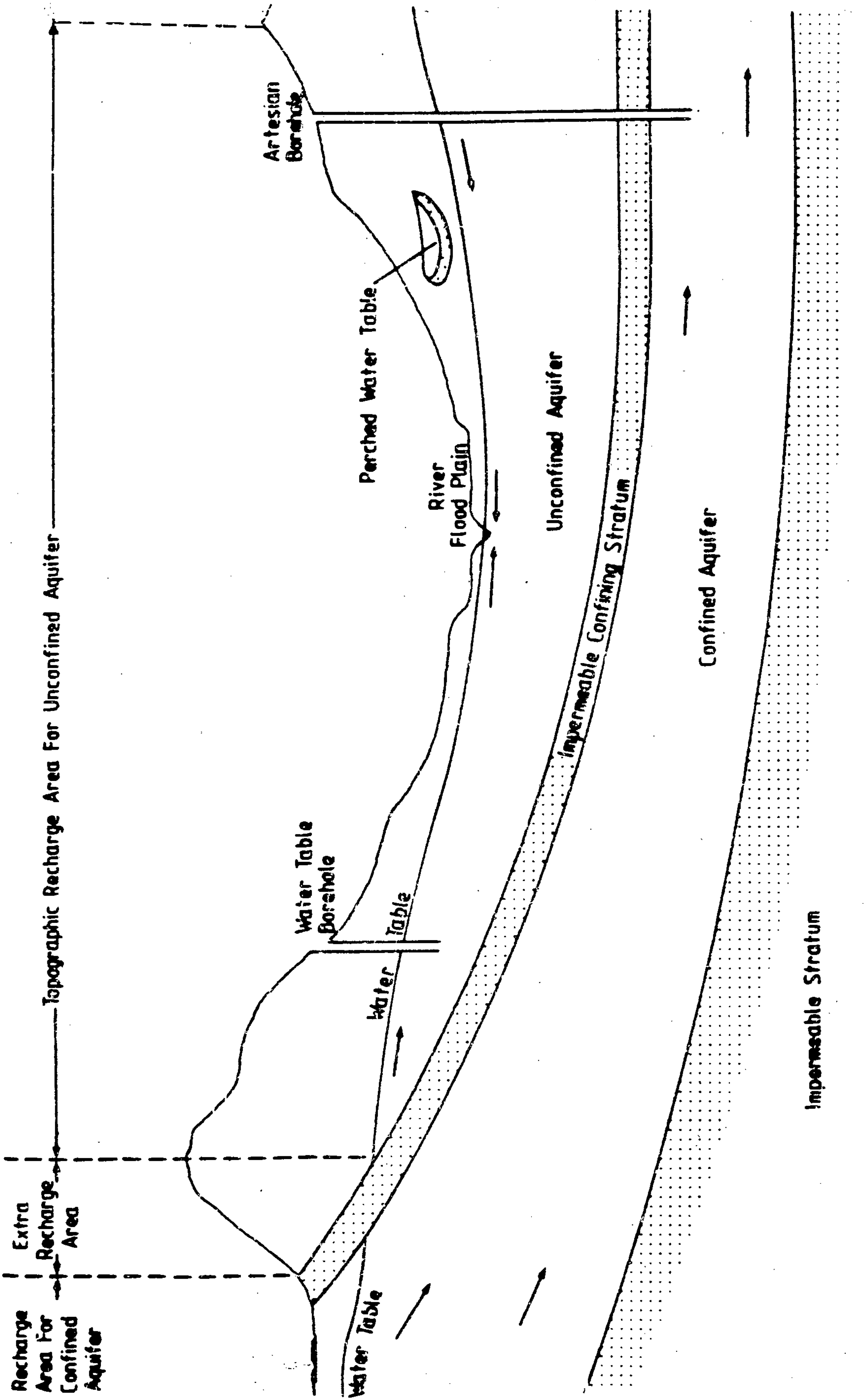


FIGURE TWO

TYPICAL SOURCES OF CONTAMINATION OF BOREHOLE WATER

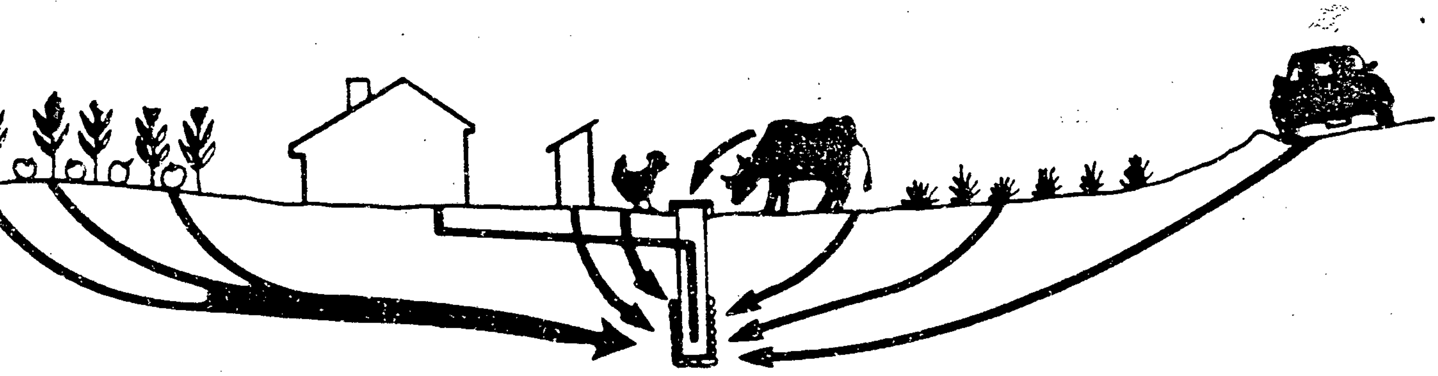
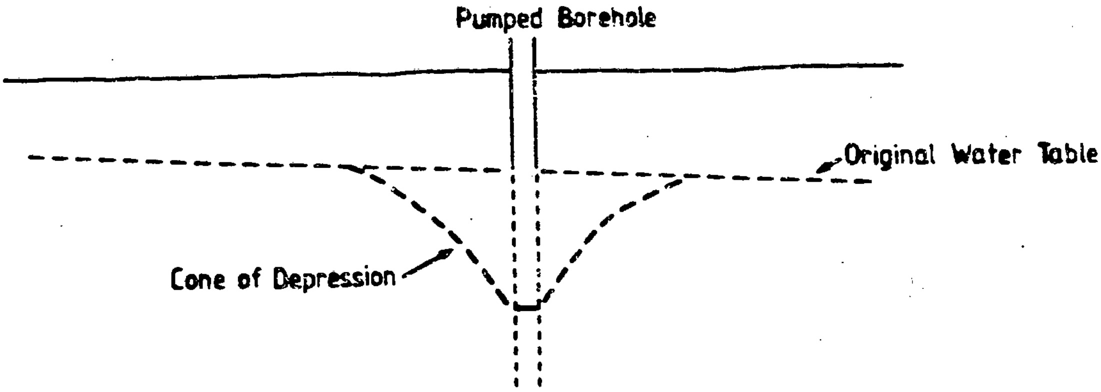


FIGURE THREE

BOREHOLE CONE OF DEPRESSION



4.3 Water Use and Level of Service

The amount of water used daily by rural households varies according to the amount of water available and the time and effort required to collect it. Hence a water supply scheme that replaces a traditional source of water should have sufficient capacity to meet the increased water use of the community.

The table below shows how the amount of water used per person per day varies with the supply level of service.

TABLE 2

RURAL WATER USE WITH RESPECT TO SUPPLY LEVEL OF SERVICE

Water supply level of service	Typical consumption (litres/person/day)	Comments
Unimproved surface source	5 - 15	Depends on distance to water.
Improved surface source	5 - 20	Increased amount of water available. Still dependent on distance to water.
Multiple standpipes or handpumps	20 - 40*	Depends on standpipe density & no. of people served by each standpipe.
Yardtaps	50 - 100	Good access to safe water results in increased water use.
Household taps	>100	Most desirable service level.

(*: Water use as low as 5 litres per person per day has been recorded in areas where the number of people served by each standpipe is high.)

The United Nations International Drinking Water Supply and Sanitation Decade has set as its criteria for an improved water supply a level of service (or availability) of 50 litres per person per day within 200 metres of the household.

<u>During the planning</u> of a water supply scheme it is common for the decision maker to either ignore the calculation of water need and use, and choose a fixed level of service such as one handpump per village, or to calculate water demand according to some predetermined formula. Both approaches have little chance of success. Unless the community is aware of the potential benefits of an improved supply and the financial limitations of the administering agency there is unlikely to be any sense of ownership or responsibility for the new system within the community.

<u>For example</u>, villagers using recently installed handpumps in KwaZulu were found to be disappointed with the schemes, for which many had contributed towards the capital cost. This was because they had been told the handpumps would provide a greatly improved supply of water. The low density, inadequate output and difficult operation of the handpumps caused villagers to continue to collect water from traditional sources.

4.4 Choosing a Water Supply Technology

The choice of water supply technology is a product of four primary considerations:

- the level of service of the scheme (single tap, multiple standpipes or handpumps, or yard taps),
- the water source (surface water, spring water or groundwater),
- the maintenance system (central responsibility, partial or full community responsibility), and
- the financial resources available.

These will determine the benefits of the water supply scheme. In particular, however, the potential benefits to the community are influenced by the service level of the scheme and its reliability. The factors influencing reliability, and options for maintenance systems, have been described in section 2.3. The service level of a scheme is often thought to increase with increasing sophistication of the water supply technology. However, it will be seen in this section that simpler technologies are capable of providing high levels of service. Further, simpler maintenance needs of a water supply technology can greatly improve a scheme's reliability.

The first step in choosing a technology should then be to assess the existing water sources in a village and determine whether these can be improved before examining alternative sources which may require more complex and costly development. Hence the development of spring water sources is addressed first in this section, followed by the choice of handpumps to extract groundwater. Finally, the criteria for selecting motorised pumps (wind, diesel, solar and electric pumps) for use in a remote village are described. Throughout this section only technologies readily available in South Africa have been included.

A summary table of water supply technologies and the considerations influencing their selection is presented on page 60. A flow chart to aid technology selection is presented on page 61, at the end of this section.

4.4.1 Spring Protection

Spring protection should be considered as an appropriate water supply technology for village water supplies in South Africa because:

- spring water is already widely used for domestic water supplies,
- it is an inexpensive and technologically simple method for improving the quality and quantity of available water, and can in some cases reduce the distance to water,
- the benefitting village can contribute greatly to a spring protection scheme such resources as materials, labour and money, and
- its simple maintenance requirements facilitate a high degree of community responsibility for servicing and maintenance. This can considerably reduce these recurrent costs for the administering agency.

The criteria for selecting a spring for protection have been reviewed in section 4.2, page 24.

Having selected a suitable spring, the protection procedure will then follows six steps:

i) A water tight box is constructed around the eye of the spring. This involves cleaning the eye and installing a filter, retaining wall and removable cover.

ii) A water collection pipe is attached to the spring box.

iii) A ferro-cement tank (or tanks) is constructed at some point below the eye of the spring. The spring water is then diverted along the pipe to this reservoir. One or more standpipes may be connected to the reservoir.

iv) An overflow pipe is connected to the reservoir. This may be used for cattle watering or garden irrigation.

v) A system of ditches is constructed above the eye of the spring. These prevent surface run-off from contaminating the eye of the spring.

vi) A fence is constructed around the spring, outside the run-off ditches, to exclude animals and animal waste which might contaminate the spring water.

The figure overleaf shows a "standard" spring development as used by the Transkei Appropriate Technology Unit, TATU. TATU has considerable experience of spring protection in a variety of differing sites and situations in Transkei. Situated in Umtata, the Media and Information Branch of TATU has produced a booklet entitled "How to Protect and Develop Springs into Permanent Rural Water Supply Systems". This describes in detail the spring protection process for most situations that are likely to be encountered, and provides estimates of the cost, labour and tools, required.

The booklet is available from:

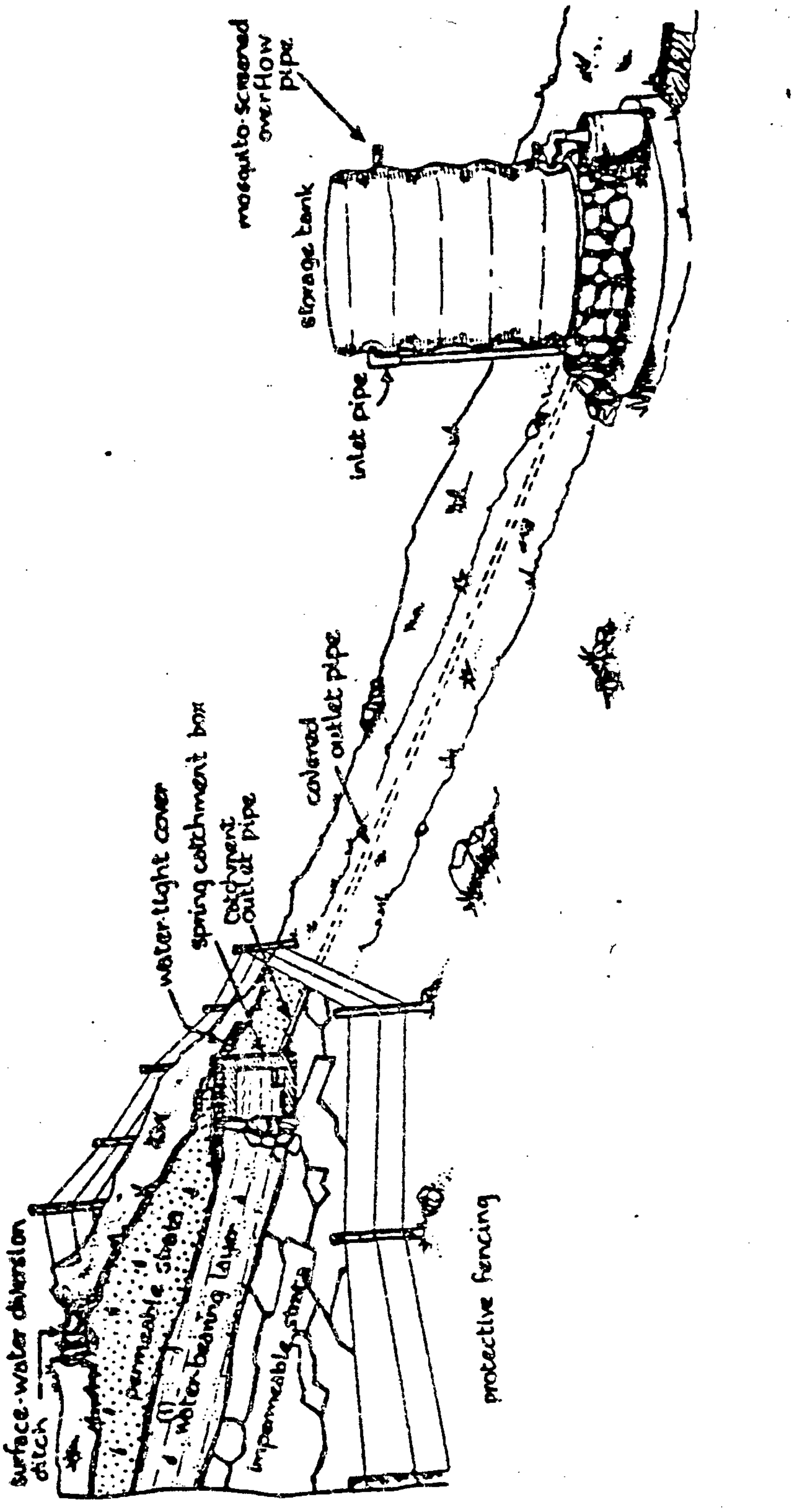
Transkei Appropriate Technology Unit
Private Bag X5029
UMTATA

Telephone: Umtata 2741

The cost of spring protection is compared to that of other water supply technologies in chapter 5.

FIGURE FOUR

STANDARD SPRING DEVELOPMENT



4.4.2 Handpumps and Foot Pumps

Handpumps are used for village water supplies in many underdeveloped areas throughout the world. A system involving handpumps can have several advantages for a village water supply:

- they utilise "free" and renewable human energy,
- they have fewer moving parts than motorised pumps and so are easier to maintain,
- if several are installed in a village, one can breakdown without jeopardising the entire village water supply.

Footpumps are discussed separately later in this section.

The successful use of handpumps is dependent upon the existence of a suitable aquifer (as described in section 4.2) and the pumping lift or head. Whilst many handpump manufacturers produce performance figures for heads of up to 80 or 90 metres, field experience of handpump projects suggests that *they should not be used at heads greater than 60 metres*. This is because handpump performance and reliability at such depths is *low*, the effort required to lift water is *high*, and maintenance is *difficult*. Also, in low yielding impermeable aquifers a drawdown of many meters of the water level may occur, increasing the pumping head and reducing the reliability of the water supply. In general, *a pump head of 45 metres should be regarded as the maximum acceptable* for a handpump. They should only be used at greater depths in exceptional circumstances.

BOX 3

A NOTE ON CORROSION

The incidence and extent of corrosion damage to pump components depends primarily on three factors:

* Pump component materials: galvanised components have little durability in even mildly aggressive water. Stainless steel or brass cylinders and plastic pipes and hoses are far preferable to galvanised mild steel or iron.

* Groundwater quality: recognising aggressive groundwater is a difficult task. Before a new scheme is implemented, any existing installations should be checked for evidence of corrosion. A high iron content of pumped water may be a sign of corrosion. Other factors, such as low pH, high conductivity, high CO_2, chloride or sulphate content can also indicate aggressive water.

* The pumping regime: this factor is often overlooked, but has a considerable influence on the quality and taste of pumped water. Levels of iron in boreholes with corroding rods will build up overnight. As pumping continues in the morning the iron content will gradually drop to its normal level again. The high iron content of this early water causes an unpleasant bitter taste, discolours food cooked in the water and stains laundry. As a result, users may reject the pump or use it only occasionally, leading to further increases in iron concentrations.

Acknowledgement: Arlosoroff et al; 1987 p55.

Types of Handpumps Available

There are two distinct types of handpumps available in South Africa: piston-cylinder handpumps and rotary positive displacement handpumps. the cost and output of commonly available handpumps are compared in Table 3 on page 47.

Piston-Cylinder Handpumps

Piston-cylinder handpumps consist of a long handle moving in vertical plane (or, in some cases, a rotary fly-wheel) moving a vertical pump rod connected to a piston with a flap valve and foot valve. A typical design of piston-cylinder handpump is shown in figure 5.

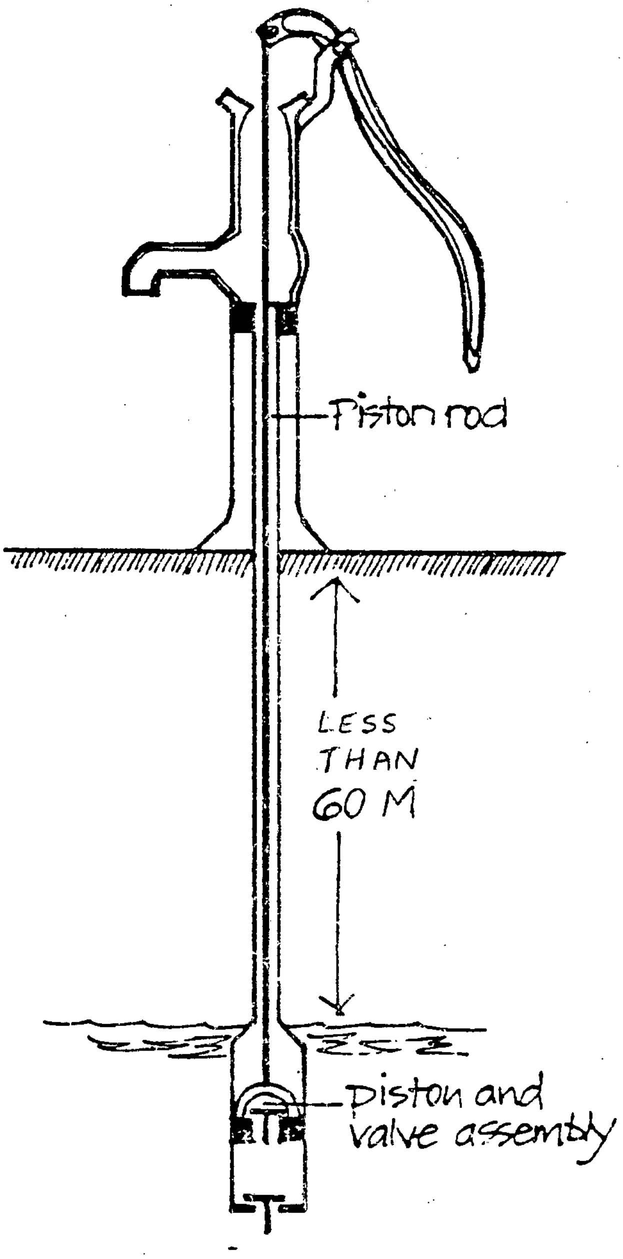
Piston-cylinder handpumps can operate in deep boreholes, but the effort required from the operator may be considerable. This is because the operator has to lift the weight of the piston rod and the mass of water in the rising main. Also, it is necessary to pump for a given period of time before any water reaches the surface.

There are three main manufacturers of piston-cylinder handpumps in South Africa: National, Nimric and Climax. The output and load tables produced by each manufacturer for their handpumps are shown in Appendix 1.

Nimric and National handpumps have been tested in the field by the KwaZulu Water Development Fund. It was found that they suffered from pilferage of exposed parts, and that the generally turbid water in the test area caused leather seals and washers to wear quickly. It was also found that the design of the handle allowed children to swing on them, causing abnormal wear and damage. Nimric has since begun to spot weld the bolts and other fittings on their handpumps. It should also be noted that the problems of misuse and pilferage can be prevented by a pump caretaker and responsible water committee.

FIGURE FIVE

TYPICAL PISTON-CYLINDER HANDPUMP



Climax manufacture two piston-cylinder handpump models: a lever type, similar to that produced by Nimric, and a flywheel type, called the Climax No 104. The 104 is available in single and double wheel models. The moving parts run in self aligning sealed for life bearings. The body barrel is of medium quality SABS tube, with a crankcase of high quality cast iron.

The most common causes of failure of piston-cylinder handpumps are

- breakages of the pump handle through wear or misuse, and
- failure of leather piston seals or the foot valve seal.

Maintenance

Changing failed cylinder components requires lifting the pump rod, rising main and cylinder to the surface, using a block and tackle or crane. This is a difficult process requiring skilled labour, and is hence beyond the scope of a community maintenance system. However, servicing and repairing above ground components can be undertaken by a trained pump caretaker. Hence, piston-cylinder handpumps are suited to the *Partial Community Responsibility* maintenance system described in section 2.3.

Rotary Positive Displacement Handpumps

In Southern Africa one company has become synonymous with rotary action, positive displacement handpumps- Mono. The handpumps are manufactured in South Africa by Mono Pumps (Africa) Pty Ltd, whose approach to handpump design is towards a "no maintenance" concept. This has resulted in a handpump design with a minimum number of moving parts - the Mono Direct Drive.

The Mono Direct Drive Handpump

The below ground components of this handpump consist of a helical rotor element inside a moulded rubber-polymer stator. The rotor is driven by a vertical drive shaft situated inside the rising main column, which is fixed directly to the handle. The operator turns the handle in a horizontal plane, rotating the shaft and rotor such that water is lifted with every turn of the handle. A foot valve is situated below the rotor to ensure that the water does not fall back when the pump is not in use. The Mono Direct Drive handpump and a schematic cross-section of the pump element are shown in figure 6.

The Direct Drive handpump has been extensively used in Southern Africa. For example, it is one of two pumps specified for village water supplies in Lesotho, and is presently the most widely adopted handpump throughout the "Homeland" rural areas of South Africa. The cost and output of the Mono handpump is compared to those of Climax and Nimric piston-cylinder handpumps in Table 3. The cost of pumped water from the different handpumps reviewed in this chapter is compared in figure 13 in Chapter 5.

Maintenance

The rotor-stator design of the Mono handpump is a mechanically simple device, operating on the archimedes principle, but which requires a considerable amount of engineering expertise to manufacture and skilled mechanics for maintenance. However, the design eliminates many of the troublesome components of piston-cylinder handpumps: there are no pins, no bushes, no leather seals, no gearbox and the very minimum of moving parts. Hence the Mono handpump is only suitable for *centralised maintenance*, as described in section 2.3.

The performance of the Mono handpump has been investigated in the field in South Africa (Wiseman & Eberhard; 1987). It has also been tested in the field by the UNDP/World Bank Project for the Laboratory and Field Testing and Technological Development of Community Water Supply Handpumps. These results are summarised below:

- Users did not like the operation of the direct drive handpump, finding it difficult to sustain effort through a complete revolution.

* The pump performed badly in laboratory endurance tests, with failures in both the drive head (now redesigned) and the pumping element.

* The delivery rate of the pump was considered to be "relatively low" compared to other pumps. This is also seen in Table 3.

* The pump design is such that key parts, such as the pump element, are replaced rather than maintained.

* Although the pump is relatively durable, maintenance is difficult and requires a fully trained mobile team.

* Finally, the progressive cavity design is more resistant to sand-laden water than other pump types.

Foot Pumps

A recently introduced technology, and one which has considerable potential for village water supplies, is foot powered pumps. A pedal powered pump is now manufactured in South Africa by Mono Pumps (Africa) Pty Ltd, following a successful test project in KwaZulu.

The pedal unit consists of a triangular framework constructed of 40 mm square tubing. This is shown in Appendix 1, together with the manufacturers performance figures. A progressive cavity Mono Pump is used, driven by a standard crank and axle arrangement. The primary sprocket drives a transfer shaft by means of a chain. The drive ratio can then be altered by changing the sprockets, which are standard bicycle types.

This form of pump has considerable potential in rural areas since pedal power is one of the most efficient means by which human power may be exploited.

FIGURE SIX

MONO DIRECT DRIVE HANDPUMP AND CROSS-SECTION OF PUMP ELEMENT

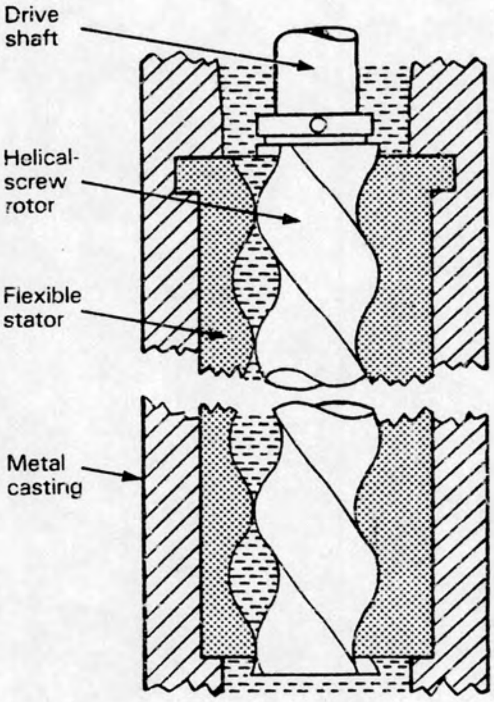


TABLE 3

COMPARISON OF SOME COMMONLY AVAILABLE HANDPUMPs

	Mono Direct Drive	Climax Lever	Climax No 104	Nimric Lever
Pump type	Progressive cavity	Piston-cyl	piston-cyl	piston cyl
30m Installation:				
Output[!]	540 l/hr	840 l/hr	810 l/hr	1635 l/hr
Cost*	R1045	R585	R1134	R580
60m Installation:				
Output[!]	360 l/hr	522 l/hr	306 l/hr	740 l/hr
Cost[*]	R1575	R951	R1486	R946

! = At 30 strokes/revolutions per minute
* = 1986 prices, excluding borehole and casing
(Note that the Climax Lever and National handpumps are similar.)

What level of service can handpumps provide?

A single handpump is capable of providing an adequate quantity of water to about 150 people, equivalent to about 30 households. Hence, a village of 600 inhabitants would require at laest four handpumps if water is to be provided to all the residents.

The capacity for handpumps to reduce the distance to water is limited. The siting of handpumps, whilst decided primarily by the availability of groundwater, must be chosen in conjunction with the people to be served. In that way there will be a better understanding of both the limitations of the handpump and its benefits.

Note: for a handpump to be installed a borehole must have a sustainable yield of at least 0.2 litres/second.

4.4.3 Wind Pumps

The use of wind powered water lifting systems is widespread in Southern Africa, both in developed and underdeveloped areas. The Transkei government for example, has purchased over 1000 windmills in recent years for use in supplying the domestic water requirements of its villages. A typical wind powered system will lift water from a borehole to a reservoir. The water may then be piped under gravity to standpipes, or collected by villagers directly from the reservoir.

Windpumps have three main advantages for village water supplies:

* they utilise the free wind energy resource,

* they have fewer servicing and maintenance requirements than most other motorised pumps, and

* they can provide a high level of service, such as water reticulated to multiple standpipes in a village.

However, two important disadvantages of windpumps are:

* detailed knowledge of the wind characteristics of an area are required if the windmill rotor, pump and wind regime are to be correctly matched, and

* windmills require regular servicing and maintenance and an operator to furl the rotor during storms to prevent damage.

What size windmill?

An optimally sized windpump will start at the wind's average speed and furl automatically at the pump's maximum speed. This minimises mechanical stress and maximises water flow.

As a minimum the wind data needed for this is a months data from a wind chart recorder or similar instrument. By comparing this "snapshot" of a site's wind characteristics to previously gathered wind velocity distribution data, and assuming regional and seasonal characteristics exist, then an estimate of the sites yearly energy potential can be made. The energy demand (water flow rate for the population to be served and head over which water will be lifted) can then be matched to the energy availability using the following empirical formula:

$$\text{rotor area } (m^2) = \frac{\text{flowrate(litres/sec)} \times \text{head(metres)} \times 100}{(\text{mean windspeed, m/s})^3}$$

In this way the correct size of windmill for the required water supply can be chosen. (The required water output should be found by multiplying the predicted water use per person per day by the number of people to be served. An allowance should be made for population growth and water loss in the pipe network). Table 2 in section 4.3 shows how water consumption varies with level of service.

Some manufacturers claim that their windmills will pump water for an average of 8 hours a day over a year. However, field studies have shown that this is unlikely, and that an average of 4 hours is more realistic. This is important since a windmill sized for an 8 hour pumping day will provide insufficient water during calmer seasons.

What size reservoir?

A suitable reservoir must be provided with all wind pumped water supplies in order that water is available during windless periods. Sufficiently accurate wind data is usually not available to predict the longest calm period likely to occur. Hence a common practice is to provide water storage equivalent to one day's pump output. However, this has been found to be insufficient in many cases. In fact, one windless day (24hrs) necessitates two days water storage to provide an uninterrupted supply of water. Similarly, two windless days requires three days storage, and so on. Since two or three days without wind are common during certain times of the year throughout South Africa, a reservoir should hold a weeks supply of water if it is to be adequately reliable.

Servicing and Maintenance

The problems of reliability and maintenance have severely reduced the effectiveness of windpumps for village water supplies. The three most common causes of windmill breakdowns are:

- rotor failure in high winds,
- transmission (gearbox) failure on the windmill head, and
- failure of piston-cylinder seals and washers, often due to "dry" pumping.

The incidence of each of these causes of breakdowns can be reduced by the presence of a windmill caretaker. The caretaker can furl the sails in a storm, lubricate moving parts (including the gearbox) and tighten loose bolts, and stop the windmill when the reservoir is full or the borehole dry. Hence, windmills are suited to a system of *partial community responsibility*, as described in section 2.3.

Windmills available in South Africa

South Africa has a well developed windmill industry which serves primarily the needs of the developed agricultural sector. The three largest manufacturers are Climax (which is part of the Stewarts and Lloyds group), Nimric and Southern Cross. All three produce a variety of windmill sizes which use piston-cylinder borehole pumps. In addition, Climax, and another manufacturer called Midkaap Engineering, produce windmills which use the progressive cavity design Mono borehole pump.

Climax, Nimric and Southern Cross have each adopted a combination of reefing, braking and transmission systems which they believe to be the most reliable and cost-effective. Table 4 below shows the different systems for a 12 foot diameter windmill and 9 metre tower from each manufacturer.

From the table it can be seen that Nimric windmills are less expensive than Climax and Southern Cross. Nimric windmills are similar to the others except that the design utilises a flexible rubber coupling in place of a gearbox. The coupling converts the rotary action of the shaft to the required reciprocating action of the piston-cylinder.

This design has four advantages over a cast iron gearbox:

* it is considerably less expensive,
* it is easier to replace,
* it requires no lubrication, and
* it produces a short pump stroke, allowing the windmill to pump in low wind speeds.

TABLE 4

SOME CHARACTERISTICS OF WINDMILLS AVAILABLE IN SOUTH AFRICA

	Climax	Nimric	Southern Cross
Reefing speed (km/hr)	30-50 adjustable	25 adjustable	32, non adjustable gravity system
Brake	by wind only	by wind only	geared winch at ground level to reefing chains
Transmission	gearbox in oil bath	rubber coupling	gearbox
Price (Head & 9m tower)	R3325	R2123	R3325

4.4.4 Diesel Pumps

The use of diesel powered engines to power water lifting devices is widespread throughout the developed agricultural sector is South Africa. Diesel pumps are popular because of their compact size, high power to weight ratio, instant start-up ability and their familiarity to farmers.

In underdeveloped areas, however, the use of diesel powered systems is subject to several severe disadvantages. The most common of these are:

* difficulties in obtaining regular diesel supplies,
* the high cost of diesel in remote areas,
* the difficulty of maintaining a diesel pump, and
* the difficulty of collecting regular cash contributions to buy fuel.

These problems have severely reduced the success of diesel powered village water supplies. In particular the reliability of diesel powered supplies has been found to be low. This is because the system does not supply water whilst money is collected to buy diesel, or whilst waiting for a broken diesel engine to be repaired. For these reasons an extensive multi-disciplinary study in Lesotho recently concluded that:

> *"we do not consider diesel pumps appropriate for water supplies to small communities like Lesotho's villages. The only rural communities for which they might be suitable would be those adjacent to missions or other institutions with the financial, technical and manpower resources to take full responsibility for their operation and maintenance".*

Acknowledgement: Feachem *et al;* 1978 p32

Maintenance

A diesel engine, properly installed, serviced and maintained, can provide 10 000 hours or more of trouble free pumping before an overhaul is required. However, there are several pitfalls that can reduce the service life markedly.

Firstly, the engine must be properly mounted on a concrete foundation block. If it is not, then the effects of vibration will damage the engine.

Secondly, it is necessary to choose the correct size of engine for the output required. If it is to run continuously for long periods then it is necessary to select an engine with a rated output greater than that required, since the maximum sustainable output is usually at a speed about 70 to 80% of its rated speed. Running an engine slightly below its rated power also gives a higher efficiency and avoids premature wear. The mechanical efficiency of the transmissions, pump and pipes must also be taken into account when sizing an engine for a particular application.

Thirdly, a new engine requires a full service after about 25 hours of use. This includes relatively difficult tasks such as re-torqueing the cylinder head and adjusting the tappets. Manufacturers usually detail these requirements in a servicing manual, but a sufficiently skilled person may not be available to carry out the service.

Hence, diesel systems are only suitable for a *centralised system of maintenance*, as described in section 2.3. Nevertheless, a village operator would improve the reliability of a diesel powered supply by filling the diesel tank, starting and stopping the engine when required, and lubricating moving parts.

4.4.5 Solar Pumps

Solar powered water pumping systems require the conversion of incident solar energy to mechanical energy. This can be done using a solar thermal device or photovoltaic cells. Solar thermal devices are available in South Africa, but are limited to low heads and flow rates, and hence are not suitable for village water supplies.

Photovoltaic (PV) devices convert solar energy to electrical energy, which is then used to drive an electric motor and pump. Schematic diagrams illustrating various solar pump configuration are shown in figure 7.

Designing a solar powered village water supply

The successful design and implementation of a solar pump requires a considerable amount of site evaluation and data. This is because it is necessary to size the PV array such that an adequate amount of water is supplied all year round.

First, it is necessary to know accurately the amount of solar energy available throughout the year. The use of mean annual solar insolation data is not sufficient, since a system based on this figure will be unable to meet the water demand in months of low solar insolation. Month by month data on the solar energy available is required.

Secondly, it is necessary to know accurately the amount of water required throughout the year. Domestic water use will have a small seasonal variation, according to drinking, cooking, and hygiene needs. If water is used for agricultural purposes the amount required will vary considerably throughout the year.

Having both sets of data (water needs and solar energy), a design month can be chosen. This is the period during which the water demand is a maximum with respect to the available solar energy. Using the required water output for this month, and an efficiency factor for the conversion of electrical energy to hydraulic potential energy, the required power output of the PV array can be calculated. The size of the PV array is then determined according to the amount of solar energy available in the design month and the PV array power output needed.

An example of this calculation is shown in figure 8. The specifications of a commonly available solar PV module are shown in the Appendices. The system represented in figure 8 consists of a PV array, a DC/DC converter, a DC motor and progressive cavity Mono borehole pump. Typical efficiencies at each stage of power conversion are shown.

The choice of electric motor and pump sub-system requires careful consideration. This is because the sub-system must operate reliably and efficiently over a range of voltage and current levels as the sun's intensity varies during the day. Two consideration are particularly important in this respect:

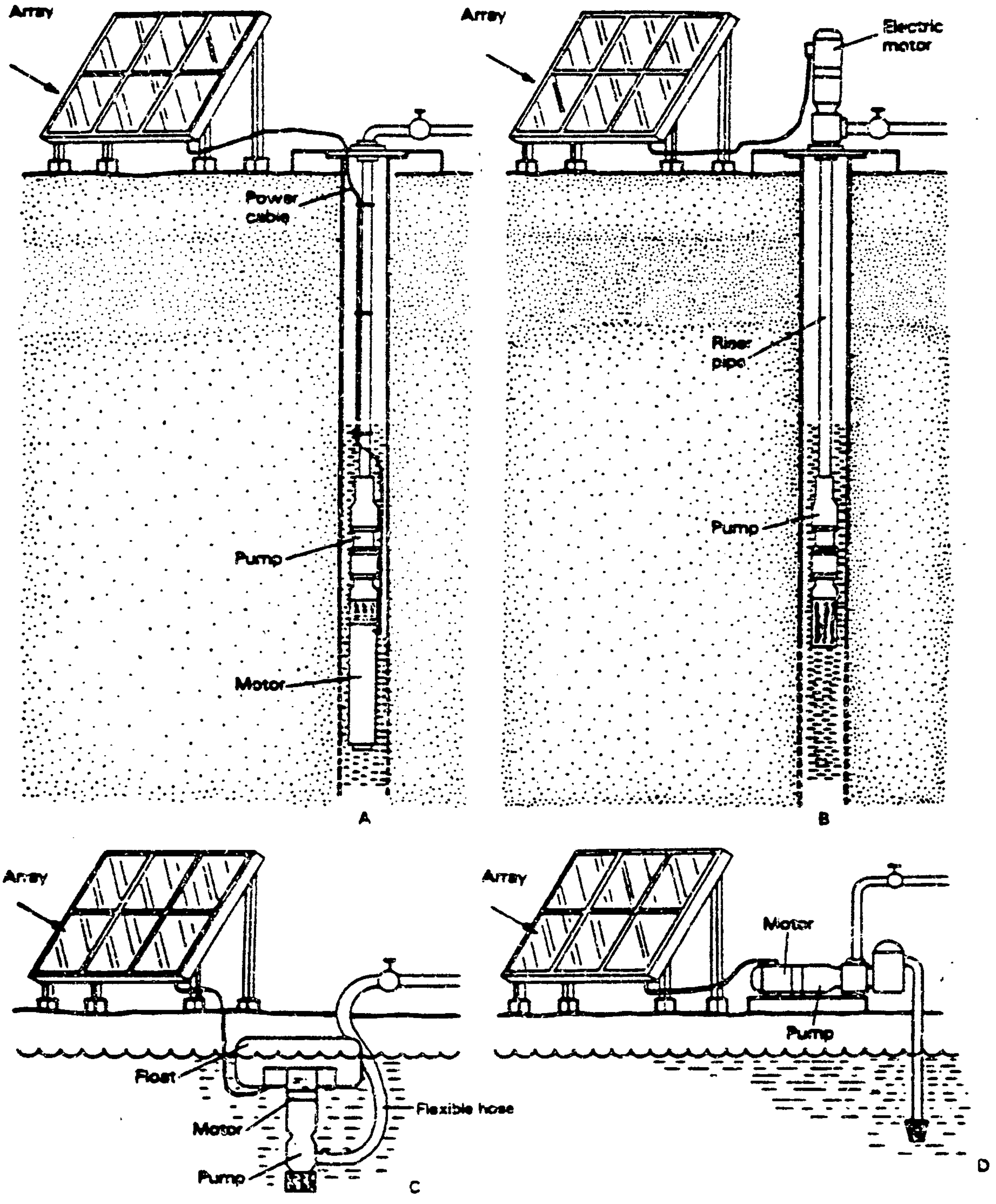
1) The starting threshold of the sub-system. For positive displacement reciprocating pumps, the motor has to overcome the starting torque of the pump. A centrifugal type pump also has a starting threshold, below which water will not be lifted. The starting threshold of a progressive cavity pump is much lower than either a reciprocating or centrifugal pump.

A typical starting threshold for a solar pump unit is an irradiance of 300 W/m^2. Hence, on overcast days, when the irradiance may not exceed 300W/m^2, the pump will not lift any water.

2) The type of power conditioning device and electric motor. The power conditioning device is installed between the PV array and the motor. Its function is to maximise the current level such that the motor operates effectively at low insolation levels.

FIGURE SEVEN

EXAMPLES OF SOLAR PUMP CONFIGURATIONS



A. submerged motor/pump set
B. submerged pump with surface motor
C. floating motor/pump set
D. surface motor with surface mounted pump

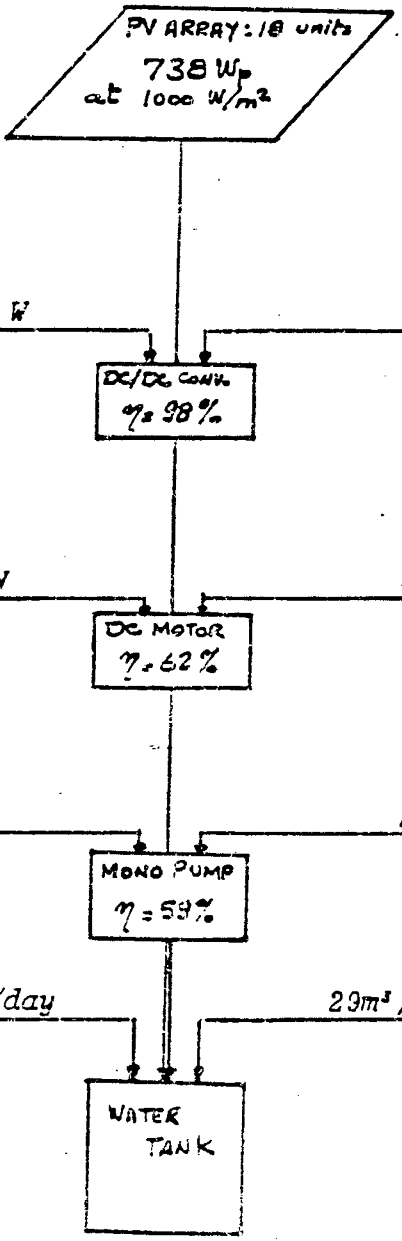
FIGURE EIGHT

TYPICAL EFFICIENCIES AND DESIGN OF A SOLAR PUMP

SOLAR PV MAX POWER: 760 W *TOTAL HEAD: 14.5 m.*
PUMP MAX POWER : 1.1 kW
WATER FLOW : 17 m^3/day

CALCULATION:

1. *No. OF SOLAR PV PANELS:* $\frac{760\ W}{41\ W}$ *= 18.5 units . SAY 18 units*
2. *TOTAL MAX POWER AVAILABLE: 738 W AT 1000 W/m^2.*
3. *SOLAR PV PANELS CONNECTION: 9 series X 2 parallel.*



JUNE *DECEMBER*

4. *POWER TO DC/DC CONVERTER:*

$\frac{377 W/m^2 \times 738 W}{1000\ W/m^2}$ = 278 W   463 W = $\frac{627 W/m^2 \times 738 W}{1000\ W/m^2}$

5. *POWER TO DC MOTOR:*

278 W X 0.98 = 272 W   454 W = 463 W X 0.98

6. *POWER TO PUMP:*

272W X 0.62 = 169 W   282 W = 454 W X 0.62

7. *WATER FLOW:*

2.35m^3/H X 7.7H =18m^3/day   29m^3/day= 3.8m^3/H X 7.7 H

Two commonly used power conditioning devices are d.c. to a.c. inverters and batteries. The use of inverters allows the designer the choice of a wider range of a.c. motors than d.c motors, which also tend to be more expensive. Disadvantages of using an inverter are the additional costs, which may offset the saving on an a.c. motor, an energy loss (although some manufacturers claim efficiencies greater than 90% for their inverters), and a reliability loss.

Batteries are used as power conditioning devices as they provide continuous energy storage, such that the lower irradiance levels are not wasted, and they operate at a fixed voltage. An on/off switching device coupled to batteries can allow the pump to operate as long as the battery output remains above a certain value. When the output drops below that value the pump is automatically switched off. The batteries can then recharge. Disadvantages of batteries are that they have a low efficiency of energy storage and a short lifetime relative to other components of the system.

Maintenance

Solar power water lifting systems have very few regular servicing and maintenance requirements. The solar panels need to be kept clean and free of dust. An electronic power conditioning device, such as an inverter, should need no maintenance. Batteries, on the other hand, will need to be replaced at intervals of, say, every year.

The lifetime of the carbon brushes of the d.c. motor in the system shown is about 2000 to 2400 hours. At an average of say, 7 pumping hours per day, this represents 285 to 343 days before replacement is required. Finally, the pump unit will be subject to the normal wear and tear associated with regular use.

Although the maintenance requirements of the system are relatively low, it is possible that a simple electrical fault, such as a loose wire, could not be traced and repaired in a village. Furthermore, the servicing and repair of electric motors and control systems can only be undertaken by a skilled technician. Hence solar PV pumps are only suitable for *centralised maintenance* systems, as described in section 2.3.

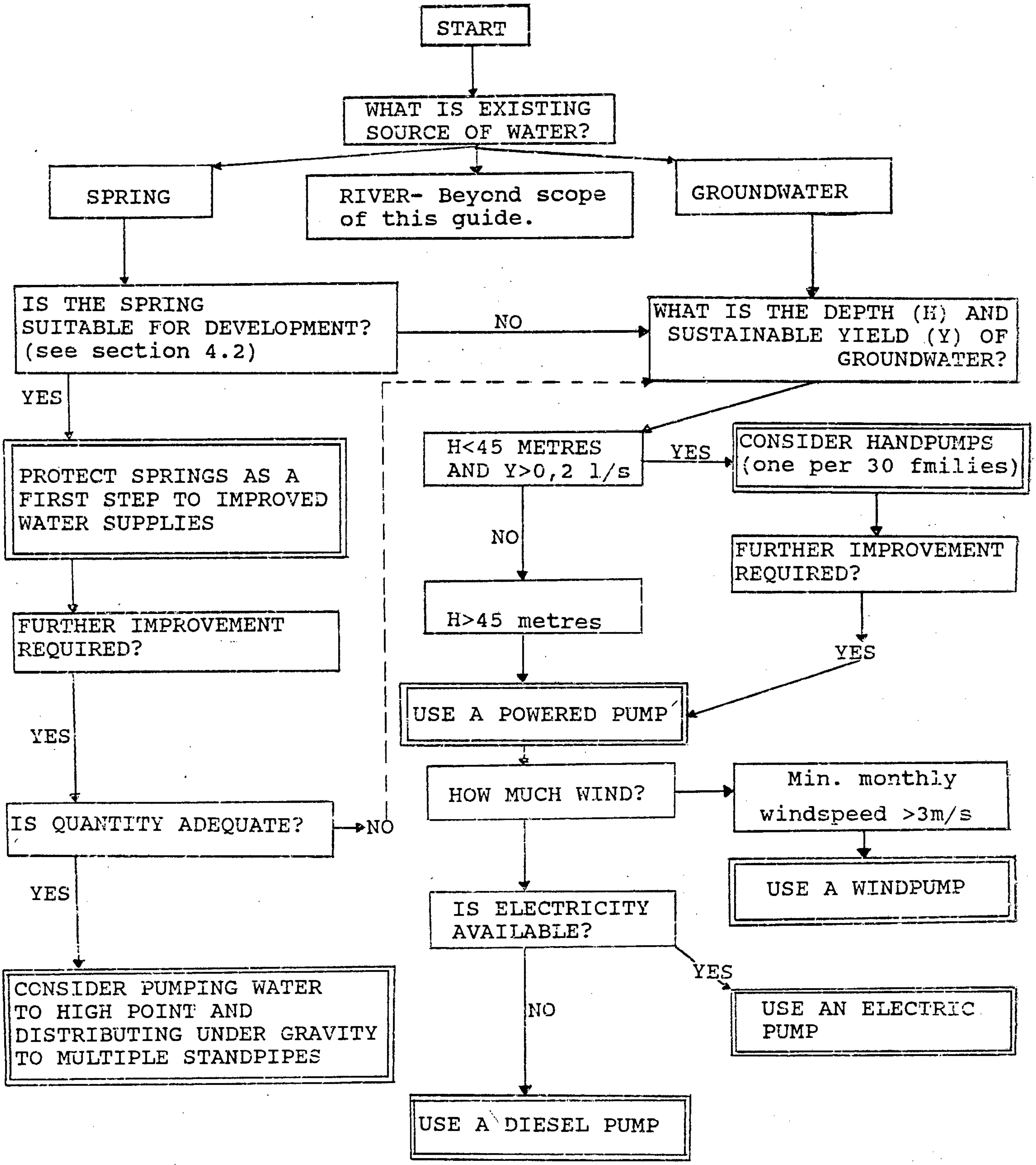
TABLE FIVE

SUMMARY TABLE OF VILLAGE WATER SUPPLY TECHNOLOGIES

TECHNOLOGY	APPLICATION	ADVANTAGES	DISADVANTAGES
SPRING PROTECTION	First step to improved water supplies.	Low cost. Simple servicing and maintenance.	Spring may be below homesteads. Limited ability to reduce distance to water.
HANDPUMPS	One handpump per 30 families. Heads <45 metres.	With careful siting can improve quality and quantity, and reduce distance to water.	Multiple handpumps and boreholes needed for larger communities. Repair of below ground equipment requires trained personnel.
WINDPUMPS	Areas with mean wind-speed > 3m/s. Suited to large heads and flow rates.	Free energy source. Low servicing and maintenance compared to other powered pumps, if preventative servicing is done.	Repair of gearboxes requires trained personnel. Susceptible to storm damage unless an operator is available.
DIESEL PUMPS	Best suited to large villages that have diesel and servicing facilities available.	High water output over large heads.	Regular servicing needed, requiring technical skill. Diesel supplies are unreliable in many areas.
SOLAR PUMPS	Areas where solar insolation is high all year round. (I>20 MJ/m2/day)	Free energy source. Few servicing requirements.	High capital cost. Skilled personnel needed for maintenance.

FIGURE NINE

FLOW DIAGRAM TO AID TECHNOLOGY SELECTION



CHAPTER FIVE

ECONOMIC CHOICES

The economic considerations relevant to the selection of water supply technologies extend beyond the selection of the technology with the lowest capital cost, to the choice of the most cost-effective option. This means that long term economic considerations- such as maintenance costs, running costs, pump lifetime, as well as benefits to users are taken into account.

The objective of an economic assessment of water supply technologies is then to provide a comparative figure representing the cost of supplying water for human consumption. This has been done for some commonly available water lifting technologies (Wiseman and Eberhard; 1987). This included estimates of maintenance costs, replacement costs and service lifetime, details of which are included in the report, which is available from the CSIR. These results are summarised in section 5.2.

In section 5.1 a brief discussion of the potential benefits of a village water supply scheme are discussed. It is important to appreciate the interdependence of these benefits with such factors as level of service (quality, quantity, distance and reliability), maintenance systems and institutional options, since the provision of complementary inputs to a scheme, as described in section 4.1, can reduce costs and increase benefits over the scheme's lifetime.

5.1 Costs and Benefits

The capital costs of village water supply schemes can vary from R1000 for a spring protection scheme with one ferrocement reservoir and standpipe, up to over R100 000 for a windpumped water supply reticulated to multiple standpipes. The per-capita costs also vary widely, but some less expensive technologies are capable of providing high levels of service to relatively large numbers of people.

The range of capital costs and number of people served for some commonly used technologies are compared in the table below: (1987 prices)

Technology	Capital costs	Number served
Spring protection	R1000 - R10 000	100 - 500+
Handpump	approx R5000	approx. 150
Windpump *	R100 000+	500 - 1000
Diesel pump *	R10 000+	500 - 1000

(Note: the costs given are for comparison only and include borehole drilling and casing, labour, reservoirs and pipes)

The benefits from a successful water supply scheme can be immediately visible. They include

- reduced effort and drudgery to collect water,
- reduced time to collect water,
- improved family and community health, and
- a better standard of living.

Some benefits, such as a reduction in the time and energy to collect water, can then lead to increased time for tending gardens, looking after children and more generally productive activities. Other, less visible benefits, such as increased levels of organisation and institutional capacity in a village, can also lead to more productive activities, raising the general quality of life of the villagers.

5.2 Economic Analyses

The cost of pumped water in $c/m^3.m$ (cents/volume flow rate x head) for a variety of commonly available water lifting technologies is shown in figures 10 and 11. Figure 10 shows the pumped water costs for a head of 30 metres and flow rate of 5,10,30 and $50m^3$/day. Figure 11 shows these costs for a 60 metre head. All figures are for 1987 prices.

The pumped water cost is based on the lifecycle cost of each technology, including estimates of maintenance costs over pump lifetime, replacement costs and the effects of inflation over a 20 year period. The cost of pump installation for these analyses includes the pump and power source (wherever applicable) and the below ground rising main, pump rods and cylinder. The cost of borehole drilling and casing was excluded, as was the cost of reservoirs and reticulation systems.

Figure 12 shows a graph of the effect of changing maintenance costs (as a percentage of capital costs) on the cost of pumped water for some commonly used pumps. Finally, figure 13 shows the cost of pumped water using various handpumps for heads of 30 metres and 60 metres and flow rates from 5 to $50m^3$/day, and figure 14 the costs of pumped water using various windmills.

It can be seen that each of the commonly used technologies has advantages over the others at certain head and flow rate conditions. At a head of 30 metres and flow rates of 5 and $10m^3$/day the Climax and Nimric piston-cylinder handpumps have the lowest pumped water costs. At higher flow rates over 30 metres, windpumps and diesel pumps become more competitive. This is not only because their pumped water costs have fallen, but also because these technologies are capable of meeting these flow rates from a single borehole. For example, a flow rate of $30m^3$/day requires 7 handpumps on 7 boreholes.

At H = 60 metres and flow rates of $5m^3$/day the Climax and Nimric handpumps still appear economical, since only one installation is required. The Mono handpump appears less economical due to its higher cost and lower output.

At higher flow rates over 60 metres the choice is mainly between reciprocating and rotary windmills, and diesel systems. In this respect it is worth noting that the maintenance costs of rotary windmills are likely to be less than either piston-cylinder types or diesel pumps. The relatively short lifetime of diesel systems also makes them less economical. The Nimric windmill apears competitive with other windmill types at flow rates of up to 30 m^3/day. This is due to its lower capital and maintenance costs.

Key to Graph Notations.

Unfortunately, due to the limitations of the computer software package used for the economic analysis, it was necessary to abbreviate the names of pump systems included in the various graphs. The abbreviations are explained below:

CL= Climax Lever handpump.

MD= Mono Direct Drive handpump.

NL= Nimric Lever handpump.

CW= Climax reciprocating windmill.

M&S= M&S Rotary windmill.

D= Diesel pump system.

S50%= Solar, assuming a 50% reduction in panel costs.

FIGURE TEN

PUMPED WATER COSTS, H=30 METRES

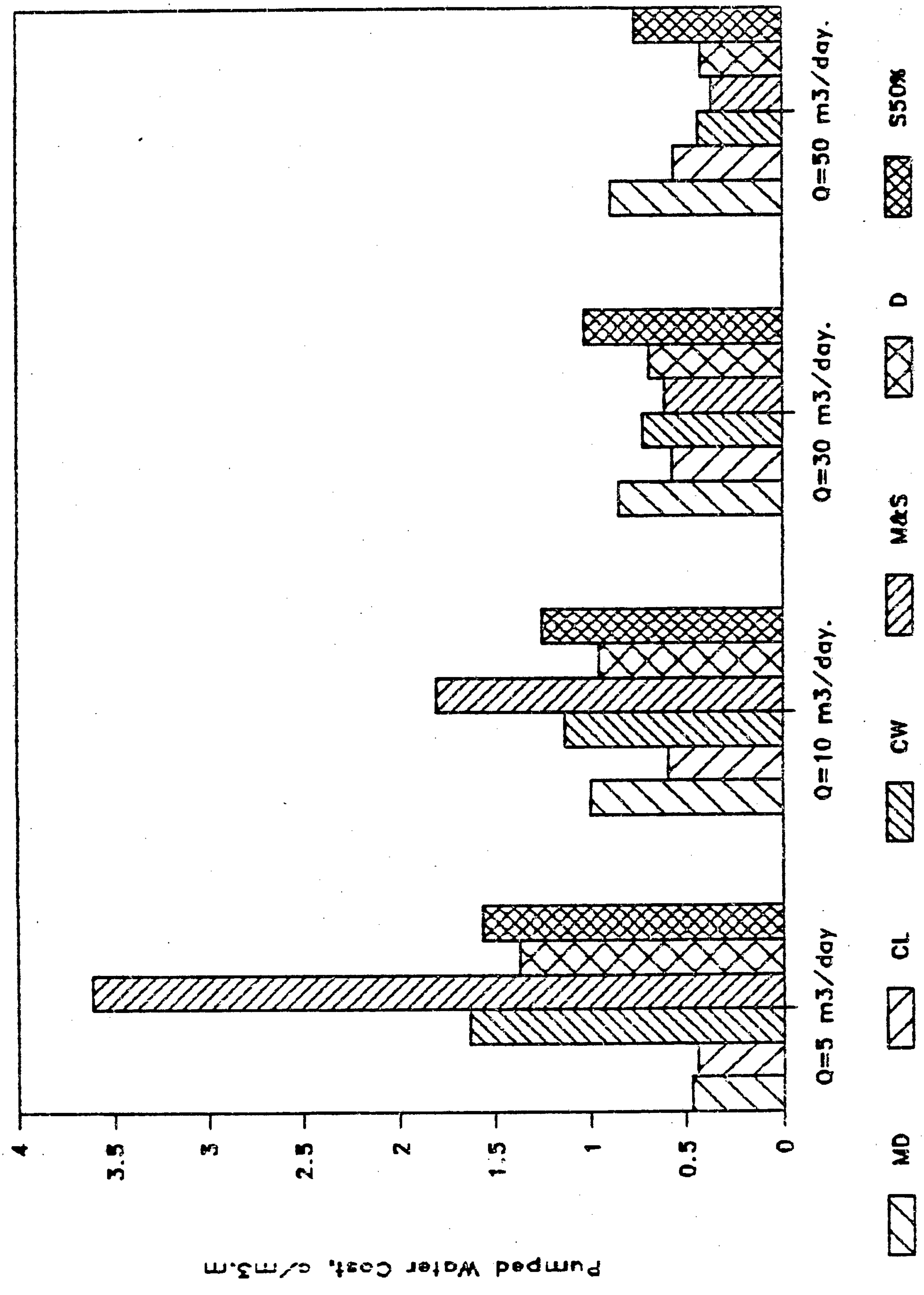


FIGURE ELEVEN

PUMPED WATER COSTS, H=60 METRES

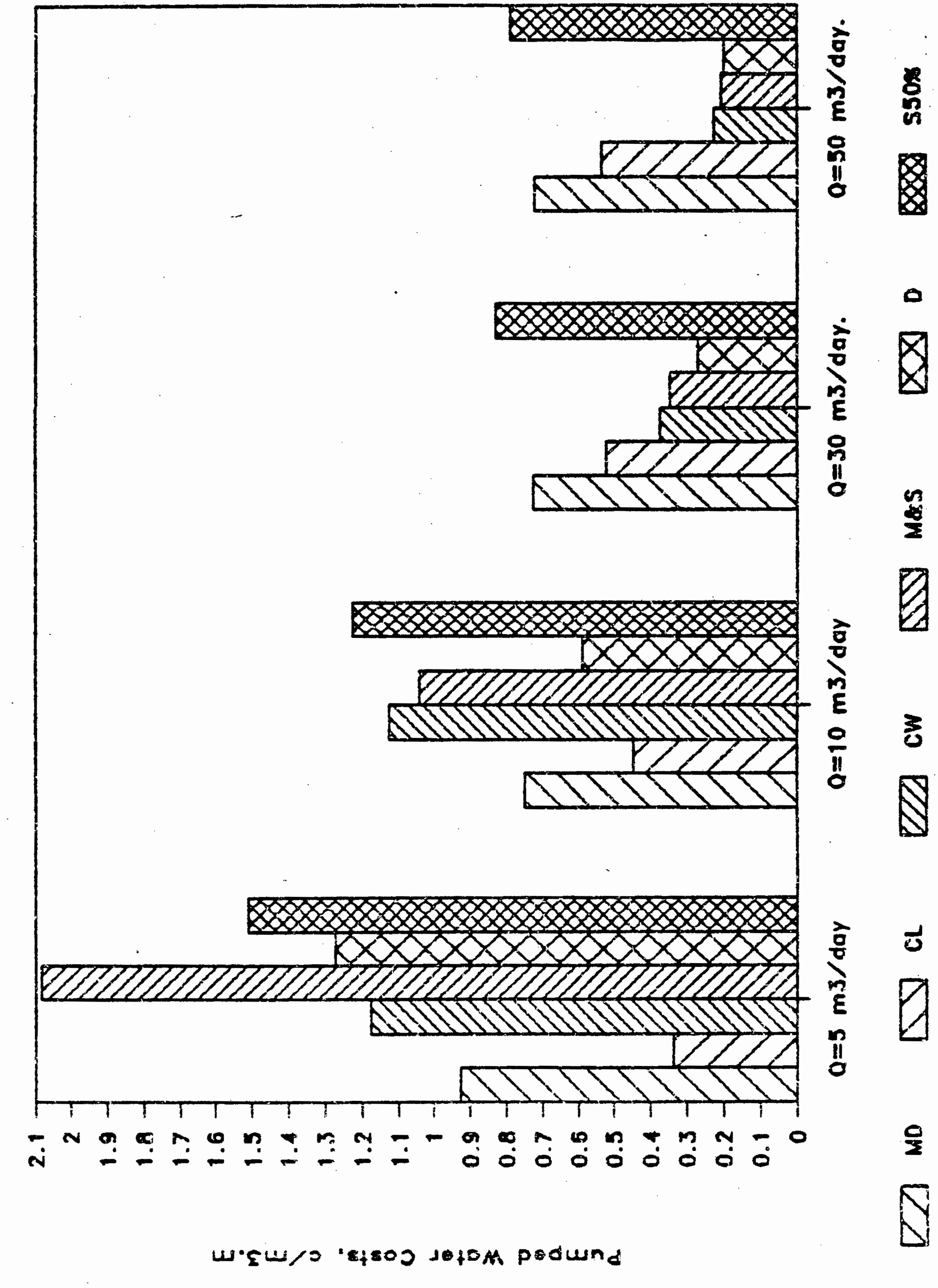


FIGURE TWELVE

PUMPED WATER COSTS vs MAINTENANCE COSTS

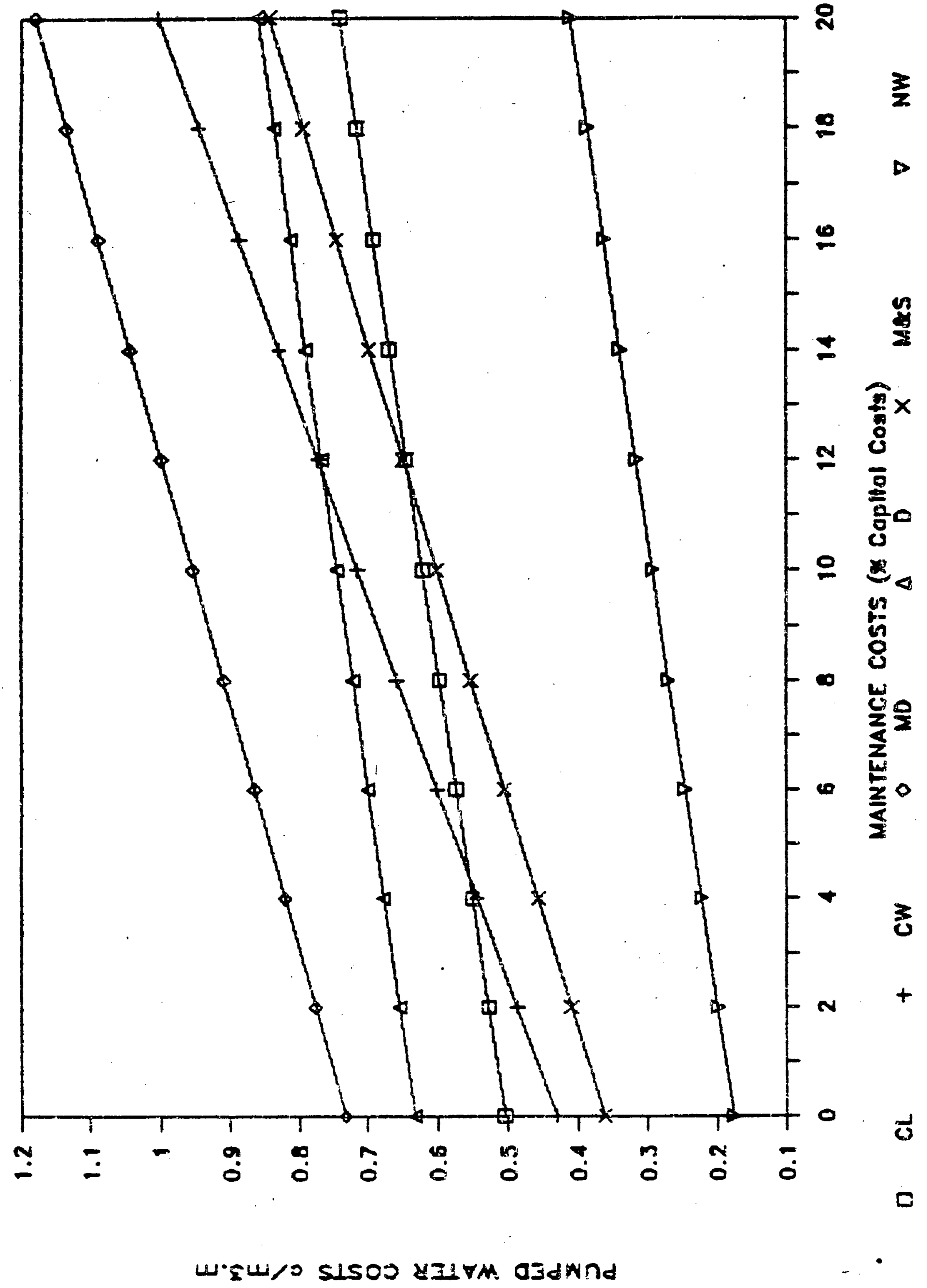
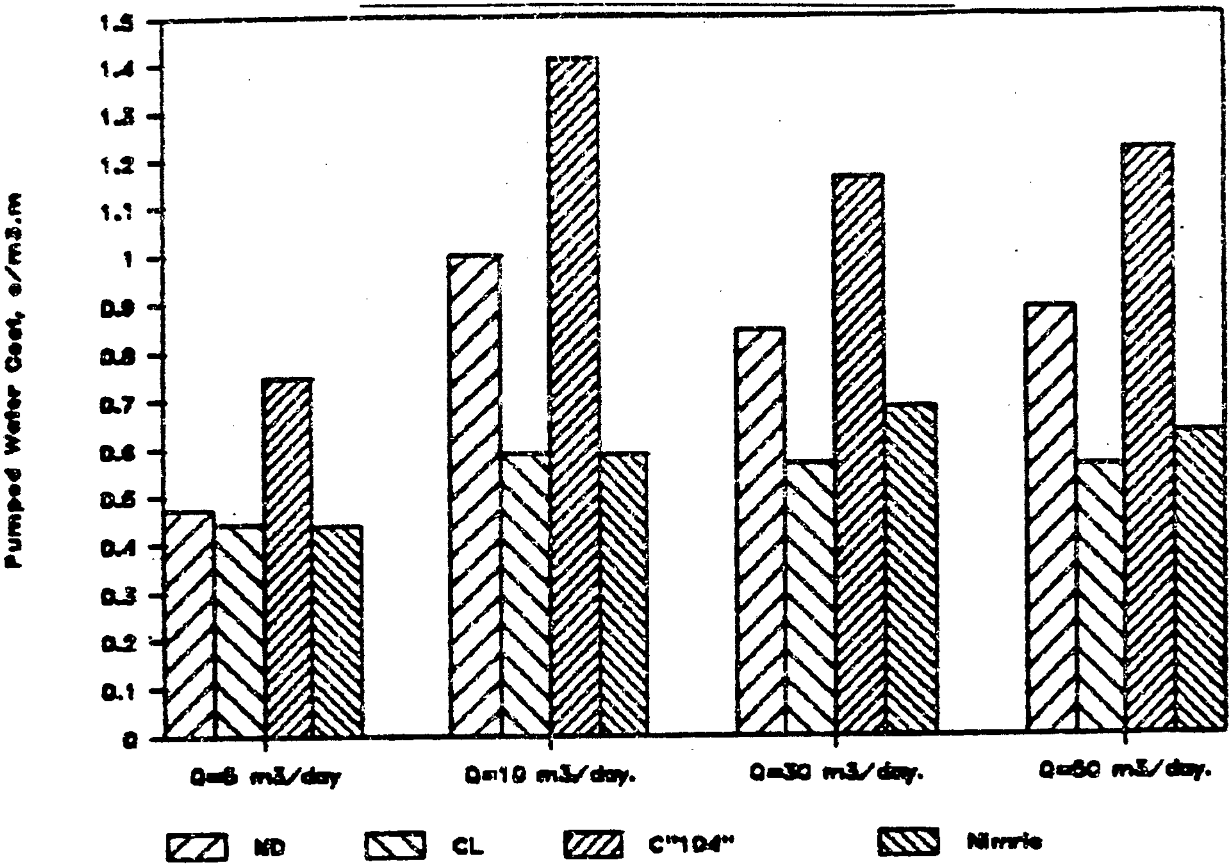
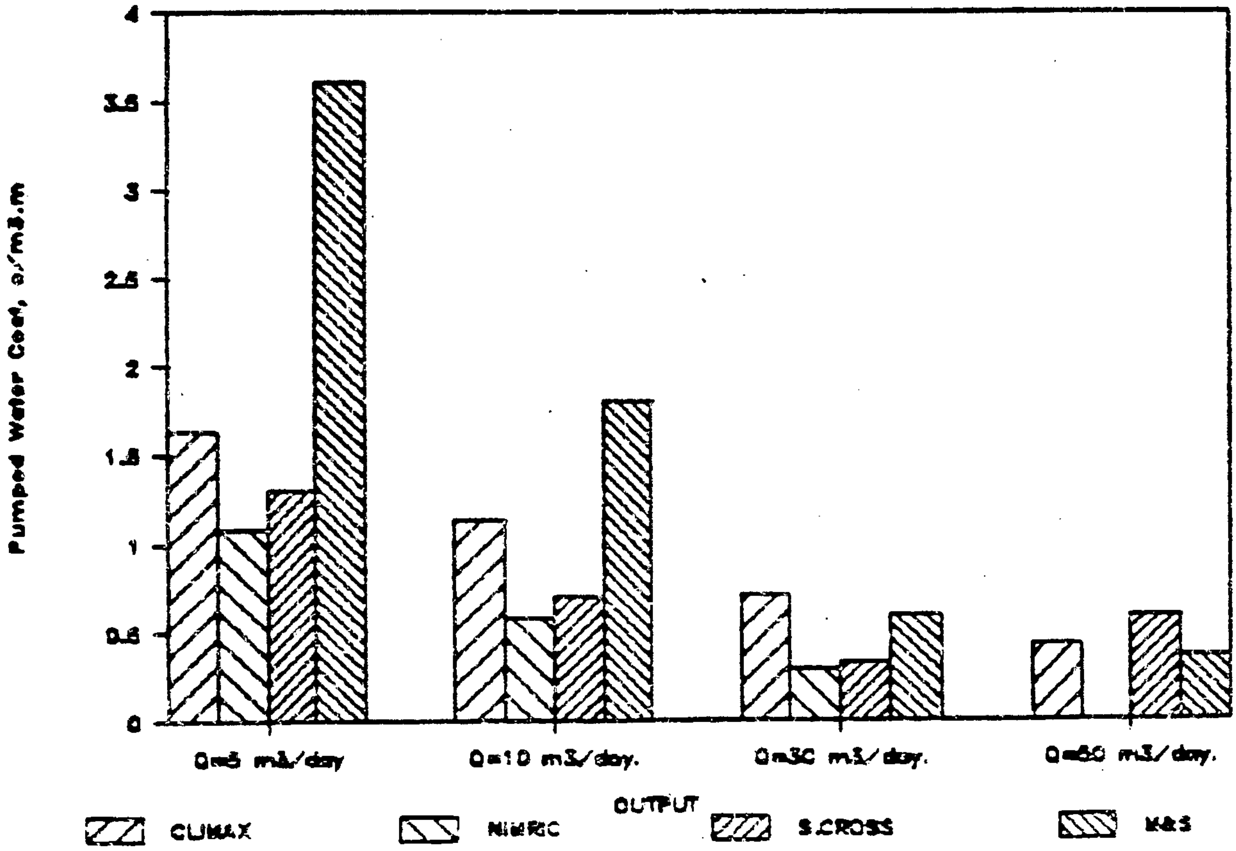


FIGURE THIRTEEN
HANDPUMPS: COST OF PUMPED WATER



WINDMILLS: COST OF PUMPED WATER



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APPENDICES

Appendix 1: Handpumps and Footpumps.

Die eerste Roterende Handpomp wat deur Mono ontwerp is, is in 1968 in diens gestel. Sedertdien het voortgesette ontwikkeling oor die jare, saam met uitgebreide ervaring in die veld, gelei tot die Direkte Aandrywing-handpompbeginsel. Dit voldoen aan al die noodsaaklike vereistes, naamlik dat die pomp onderhoudvry en van stewige konstruksie is, sowel as maklik om te gebruik. Oorweeg die unieke eienskappe wat deur hierdie revolusionêre ontwerp gebied word:

① DIE EENVOUD VAN DIREKTE AANDRYWING

Die Mono Direk-aangedrewe Roterende Handpomp is 'n voortreflike voorbeeld van verbeterde kraglewering en hoër doeltreffendheid wat behaal is deur eenvoud van ontwerp.
Die handvatsel, dryfas en pompeenheid vorm 'n enkele roterende element – tog, deur die wetenskaplike toepassing van die wette van drukking wat op die stator inwerk, is die handvatsel baie maklik om te draai en kan dit deur jong kinders sowel as bejaardes gedoen word.

② ROTERENDE POSITIEWE VERPLASING

Omdat die pomp met 'n aaneenlopende roterende aksie werk, in plaas van die heen-en-weer of ruk-en-pluk aksie, is die waterstroom egalig en nie-polsend. Daar is geen vermorste beweging nie, aangesien die vloeitempo direk in verhouding is met die spoed waarteen die pomp gedraai word.

③ GEEN VERMORSTE ENERGIE NIE

Die pomp is selfvoorvoerend maar 'n betroubare voetklep is aangebring om te verhoed dat water in die kolom terugvloei wanneer die pomp nie in gebruik is nie. Dus vind onmiddellike waterlewering met die eerste rotasie van die handvatsel plaas en gevolglik is daar geen vermorste energie nie.

④ SKUURWEERSTAND

Die ontwerp van die pompelement, die harde chroombedekte rotor en die stator van elastomeerrubber is die hoofrede vir die Mono-pomp se merkwaardige vermoë om water te hanteer wat klein hoeveelhede sand of slik bevat. Daar is geen moontlikheid dat sanddeeltjies ingebed of tussen die twee oppervlakke rondgeskuur kan word nie, dus word onnodige slytasie uitgeskakel.
Die lae stroomsnelheid van die water deur die pomp en die egalige, aaneenlopende beweging daarvan dra verder by tot minimum slytasie.

⑤ ONDERHOUDVRY

Die uitskakeling van ratte, drukstukpakking, pakstukke, dopwasters, penne, busse en silinderseëls – saam met die verseëlde smeringstelsel en voorsorg vir skuurwering – beteken minder slytasie, minder wat verkeerd kan gaan of weier. Feitlik geen onderhoud nie.

⑥ GEEN RATTE NIE

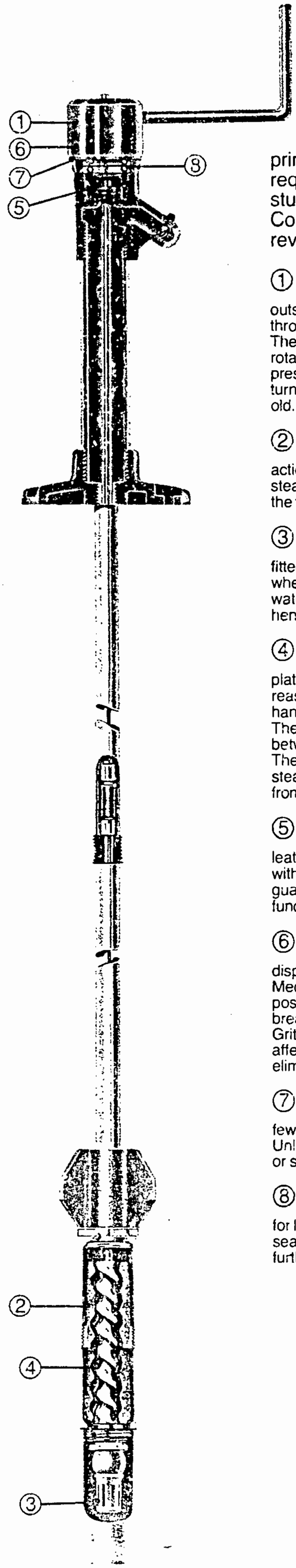
Met die beginsel van Direkte Aandrywing word daar weggedoen met ratte en kamratte, wat die gebruiker 'n tweeledige voordeel bied.
Meganiese terugskop word uitgeskakel en as sulks is daar geen moontlikheid van onbehoorlike slytasie of beskadiging aan die leweringkop weens rowwe, onegalige hantering nie.
Slytasie en skurende deeltjies, wat met ratte en kamratte gepaard gaan, en smering en derhalwe gladde werking beïnvloed, word ook uitgeskakel.

⑦ GEEN BUSSE NIE

Mono se nuwe vereenvoudigde Direkte Aandrywing-ontwerp beteken minder werkende dele, dus is daar ook minder kans op weiering. In teenstelling met suierpompe het dit geen penne, busse of seëls nie – die dele wat die meeste aan slytasie en beskadiging onderhewig is.

⑧ GEEN SMERING NIE

Die pomp is ontwerp vir langdurige werking sonder dat smering nodig is. Die verseëlde koeëllaers is voorafgepak met smeermiddel en geen verdere smering is nodig gedurende die volle gebruiksduur van die laers nie.



The first Rotary Hand Pump designed by Mono was placed in service during 1968. Since then continuous development over the years, coupled with extensive field experience, has led to the introduction of our revolutionary Direct Drive principle, incorporating all the essential requirements being maintenance free, of sturdy construction and easy to operate. Consider the unique features offered by this revolutionary design:

① DIRECT DRIVE SIMPLICITY

The Mono Direct Drive Rotary Hand Pump is an outstanding example of achieving extra power efficiency through sheer simplicity of design.
The handle, drive shaft and pump unit form a single rotating element, yet by scientific use of the laws of pressure acting on the stator, the handle is very easy to turn and can be operated by the very young or the very old.

② ROTARY POSITIVE DISPLACEMENT

Because the pump operates on a continuous rotary action instead of the reciprocating principle, water flow is steady and non-pulsating. There is no wasted motion as the flow rate is directly proportional to the speed operation.

③ NO WASTED ENERGY

The pump is self priming but a reliable footvalve is fitted to prevent the water in the column from draining back when the pump is not in use. Immediate discharge of water, therefore, occurs with the first rotation of the handle, hence no wasted energy.

④ ABRASION RESISTANCE

The design of the pumping element, the hard chrome-plated rotor and the elastomer rubber stator is the primary reason for the remarkable ability of the Mono pump to handle water containing small quantities of sand or silt. There is no possibility of grit being embedded or dragged between the two surfaces, thus eliminating excessive wear. The low velocity of the water through the pump and its steady, continuous motion further contribute to freedom from wear.

⑤ MAINTENANCE FREE

The elimination of gears, gland packing, gaskets, cup leathers, pins, bushes and cylinder seals – in combination with a sealed lubrication system and anti-abrasion safeguards – means less wear, less to go wrong or malfunction. Virtually no maintenance.

⑥ NO GEARS

With the Direct Drive principle, gears and cogs are dispensed with, offering the user a two-fold benefit.
Mechanical backlash is eliminated and as such there is no possibility of the discharge head suffering undue wear or breakage as a result of rough, jerky handling.
Grit forming wear, associated with gears and cogs, affecting lubrication and hence smooth operation, is also eliminated.

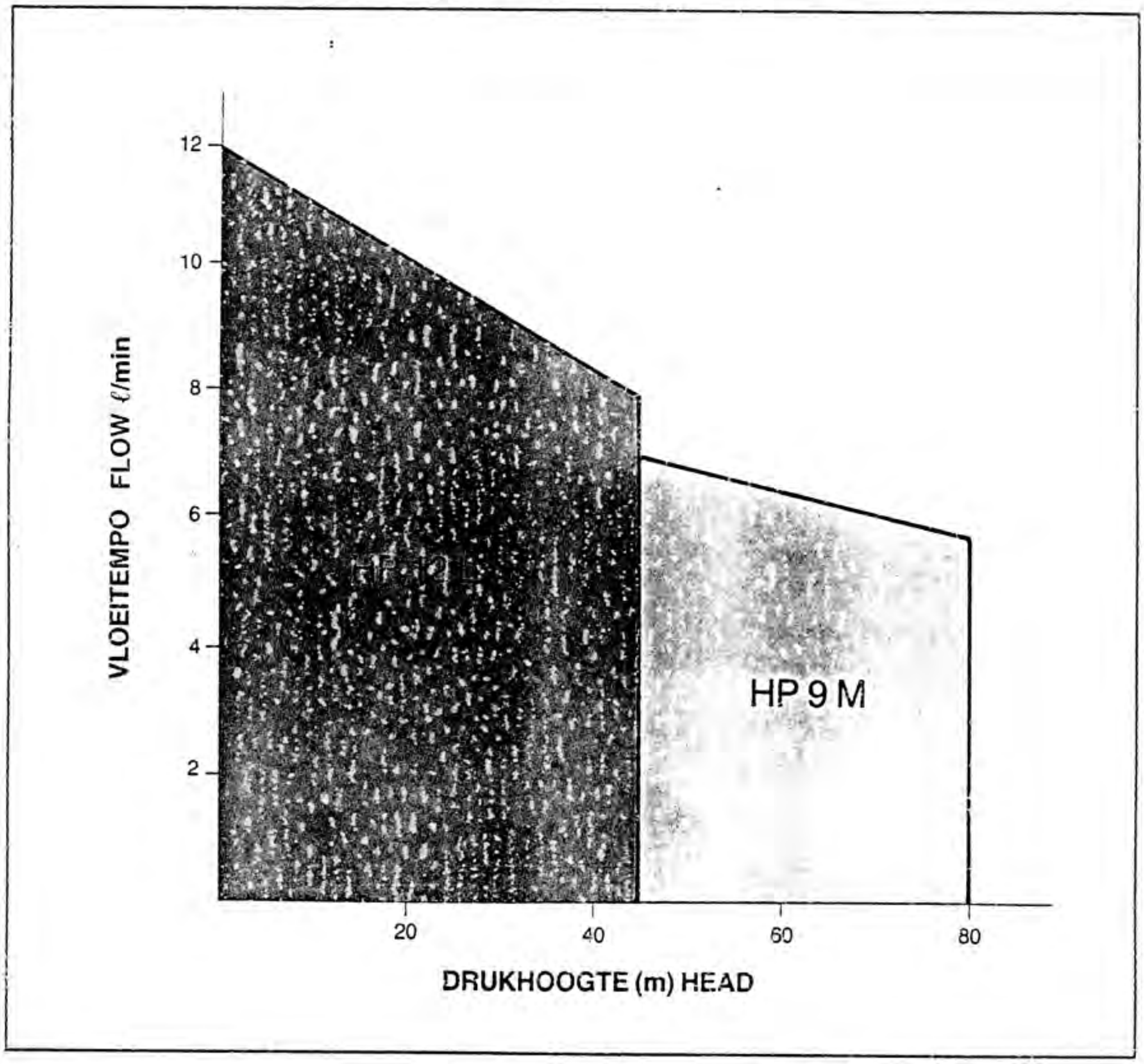
⑦ NO BUSHES

Mono's new simplified Direct Drive design means fewer working parts, so there is less chance of malfunction. Unlike reciprocating pumps, it has no pins, bushes or seals, the parts most prone to wear and damage.

⑧ NO LUBRICATION

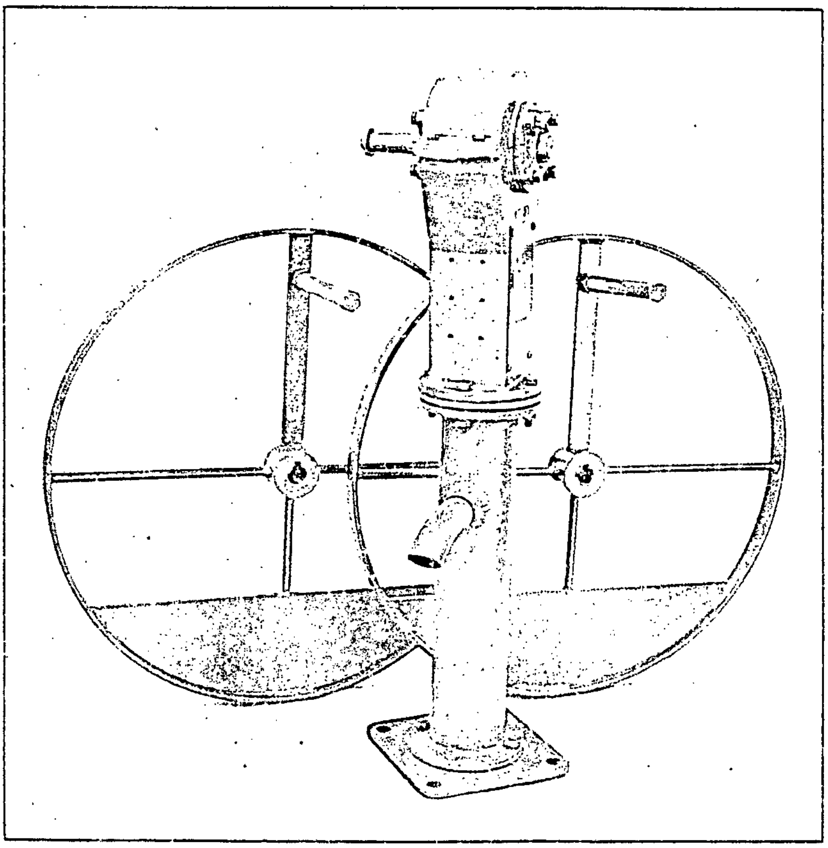
The Direct Drive Discharge Head has been designed for long life operation without any need for lubrication. The sealed ball bearings are pre-packed with lubricant and no further lubrication is necessary for the life of the bearings

Tipiese gemiddelde prestasiegids. **Typical average performance guide.**



Climax

Handpomp
Handpump



Die Climax No. 104 is 'n duursame handpomp wat sy slag onder strawwe toestande op die platteland bewys het.

Dit is 'n draai-aksie eenheid en stel lae onderhoud-vereistes deurdat die draaiende dele met lewenslank verseëlde koeëllaers toegerus is.

Die romp van die pomp is van medium, SABS gehalte pyp vervaardig en die krukkas is van hoë gehalte gietyster.

Die pomp is beskikbaar in beide enkel- of dubbel-handwiel eenhede, met of sonder 'n drukbuis-samestelling.

The Climax No. 104 handpump is a robust unit which has proved itself under arduous rural conditions.

It is a rotary action unit with revolving parts running in self-aligning sealed-for-life bearings. Maintenance is minimal.

The body barrel is of medium quality SABS tube with the crankcase being of high quality cast iron.

The pump is available in either double or single wheel models, with or without a differential tube assembly.

Afmetings

Basis tot middellyn van Handwiel	900 mm	
Basis tot middellyn van leweringsuitlaat	400 mm	
Basis vierkant	330 mm	
Gate vir montering van basisplaat 20 mm op 280 mm sirkeldeursnee		
Leweringsuitlaat	40 mm	B.S.P.
Inlaat vir stygleiding	50 mm	B.S.P.
Slaglengte	100mm	
Handwiel deursnee	100 mm	
	800 mm	

Dimensions

Base to centre line of wheel	900 mm	
Base to centre line of delivery outlet	400 mm	
Base	330 mm	square
Foundation bolt holes drilled 20 mm on 280 mm P.C.D.		
Delivery outlet	40 mm	B.S.P.
Inlet for rising main	50 mm	B.S.P.
Stroke length	100 mm	
Handwheel diameter	800 mm	

Laste Tabel/ Load Table

		liters		liters		liters	
Silinder Grootte Cylinder Size	Maksimum Drukhoogte Maximum Head	/min	/uur /hr	/min	/uur /hr	/min	/uur /hr
m	m	10 spm		20 spm		30 spm	
45	80	1,7	102,0	3,4	204,0	5,1	306,0
51	52	2,0	120,0	4,0	240,0	6,0	360,0
65	39	3,2	192,0	6,4	384,0	9,6	576,0
76	31	4,5	270,0	9,0	540,0	13,5	810,0
90	25	6,3	378,0	12,6	756,0	19,0	1140,0
102	20	9,2	552,0	18,4	1104,0	24,6	1476,0
125	13	12,7	762,0	25,4	1524,0	37,9	2274,0

N.B.

Meganies is die handpomp in staat om teen hoër drukhoogtes te pomp as wat die laste tabel aandui. Die hoogtes per silindergrootte soos aangedui is bepaal in verhouding tot die gemaklike vermoë van die gemiddelde persoon.

N.B.

Mechanically, the pump is capable of higher heads than those shown in the load tables. However, the head per cylinder size has been limited to what can comfortably be coped with by the average person.

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Climax Windmills (Pty) Limited

"L" HANDPUMP

Load Table

PERFORMANCE AT 30 STROKES PER MINUTE

Cylinder Size (mm)	40	50	65	75	90	100	110	125
Total Lift (m)	90	60	35	25	18	14	12	9
Capacity (ℓ/min)	5,7	8,7	14	19	28	35	42	55

---oOo---

NB

NIMRIC

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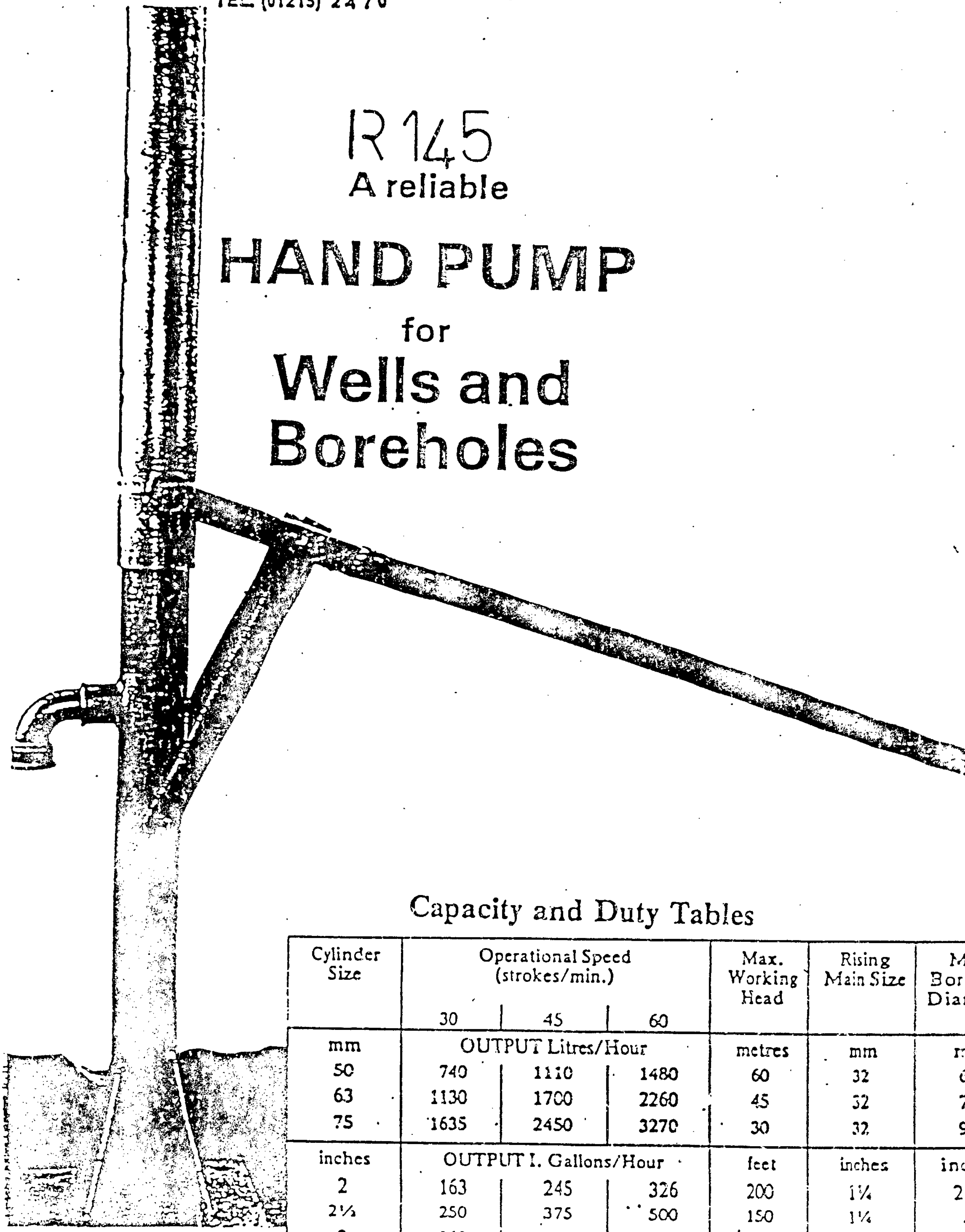


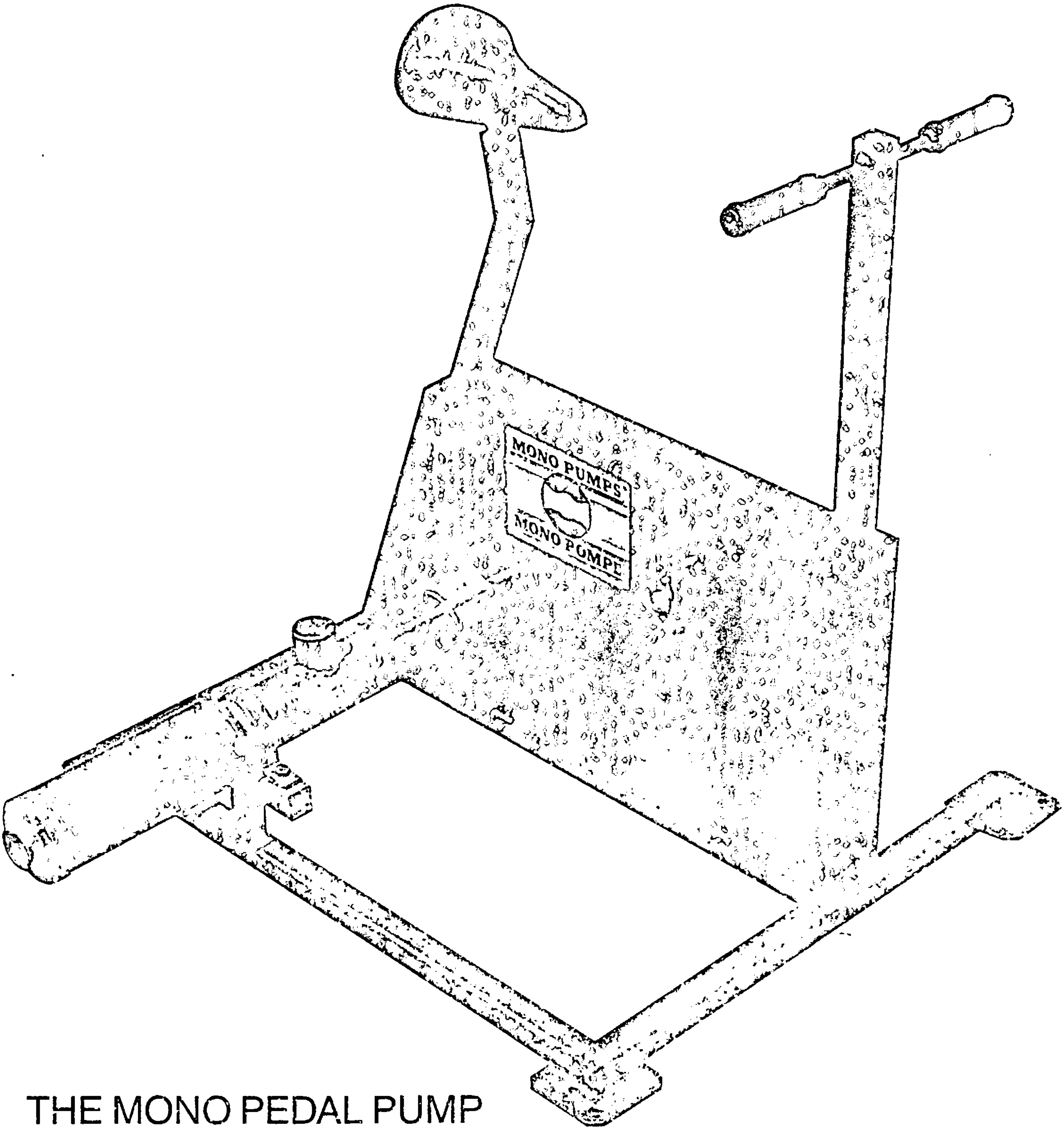
R145

A reliable HAND PUMP for Wells and Boreholes

Capacity and Duty Tables

Cylinder Size	Operational Speed (strokes/min.)			Max. Working Head	Rising Main Size	M Bor Dia
	30	45	60			
mm	OUTPUT Litres/Hour			metres	mm	m
50	740	1110	1480	60	32	6
63	1130	1700	2260	45	32	7
75	1635	2450	3270	30	32	9
inches	OUTPUT I. Gallons/Hour			feet	inches	inc
2	163	245	326	200	1¼	2
2½	250	375	500	150	1¼	
3	360	540	720	100	1¼	3

MONO



THE MONO PEDAL PUMP

DIE MONO TRAP-POMP

Mono Pedal Pump

Mono's Pedal operated pump, designed in conjunction with the Engineering faculty of the University of the Witwatersrand and other authorities for pumping from rivers, dams, reservoirs and ponds. has been engineered for rural Africa.

This pump is a further development in Mono's never ending search for water supply solutions in developing countries. The successful operating for many years of the Hand Operated Rotary Borehole pump and the recently launched Solar Lift Solar Pumping Systems has encouraged Mono to pay attention to surface water.

The unit is robustly constructed of rectangular steel. Ergonomics, comfort and ease of operation have been taken into account.

The use of a simple but robust chain drive in a number of ratios has ensured that a variety of different head conditions may be catered for.

Mono Trappomp

Die Mono Trappomp wat in samewerking met die Ingeneursfakulteit van die Universiteit van die Witwatersrand ontwikkel is, is spesifiek ontwerp vir die pomp van water van uit damme, riviere, kuile of reservoirs in onderontwikkelde Afrika lande.

Hierdie pomp is nog 'n stap verder in Mono se soeke na oplossings vir die waterverplasings probleme wat in ontwikkelende lande ondervind word. Die uiters suksesvolle gebruik van die Mono Draaiskroef Handpomp oor baie jare, asook die onlangse vrystelling van die Solarlift Solar pomp, het Mono genoodsaak om aandag te skenk aan oppervlak water.

Hierdie eenheid bestaan uit 'n taai, reghoekige staalkonstruksie, en baie aandag is aan doeltreffendheid, gerief en maklike hantering geskenk.

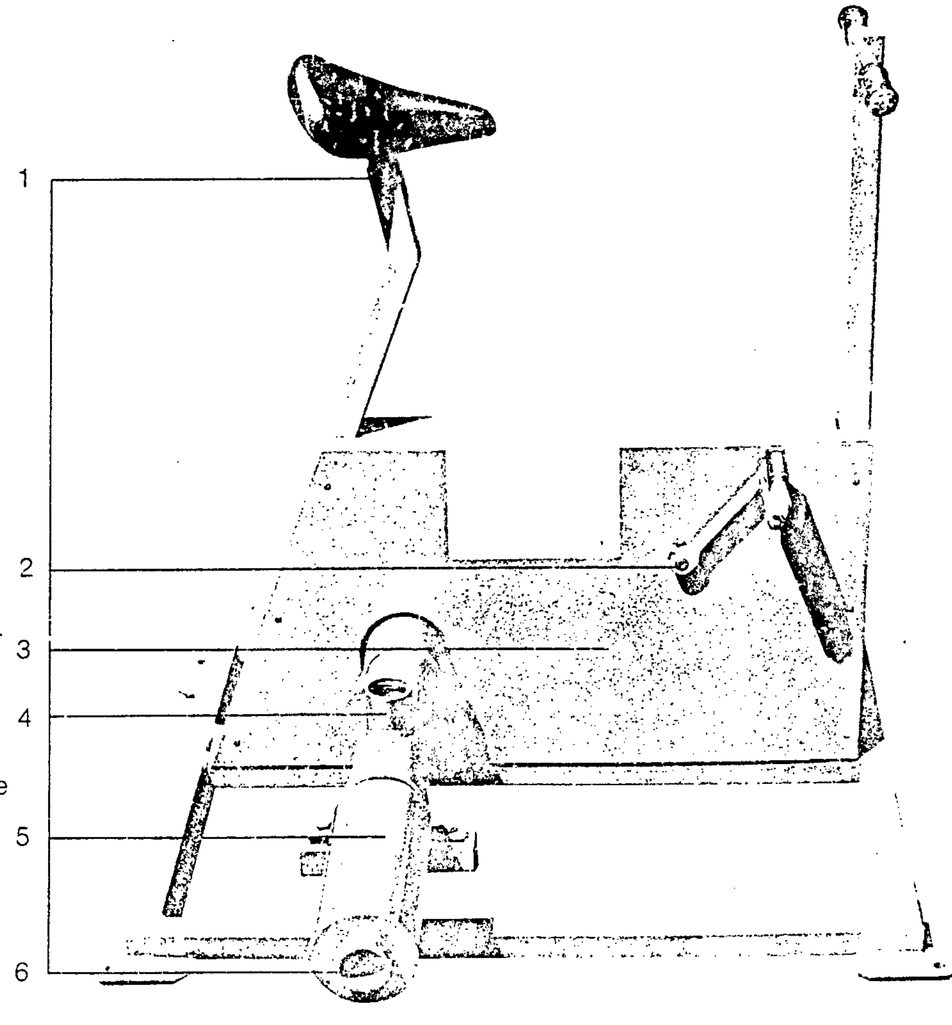
Die gebruik van 'n eenvoudige, dog sterk kettingaandrywing in 'n aantal verhoudings, het verseker dat daar vir 'n verskeidenheid druk toestande voorsiening gemaak is.

Features

1. Adjustable saddle to suit all heights.
2. Robust chain drive — assembled from easily obtainable components.
3. Safe — all moving parts properly enclosed and guarded.
4. Three ratios for differing heads:
   2:1 — 20 metres
   3:1 — 15 metres
   4:1 — 10 metres
5. Proven Mono pump Positive Displacement element.
6. Inherently self priming.

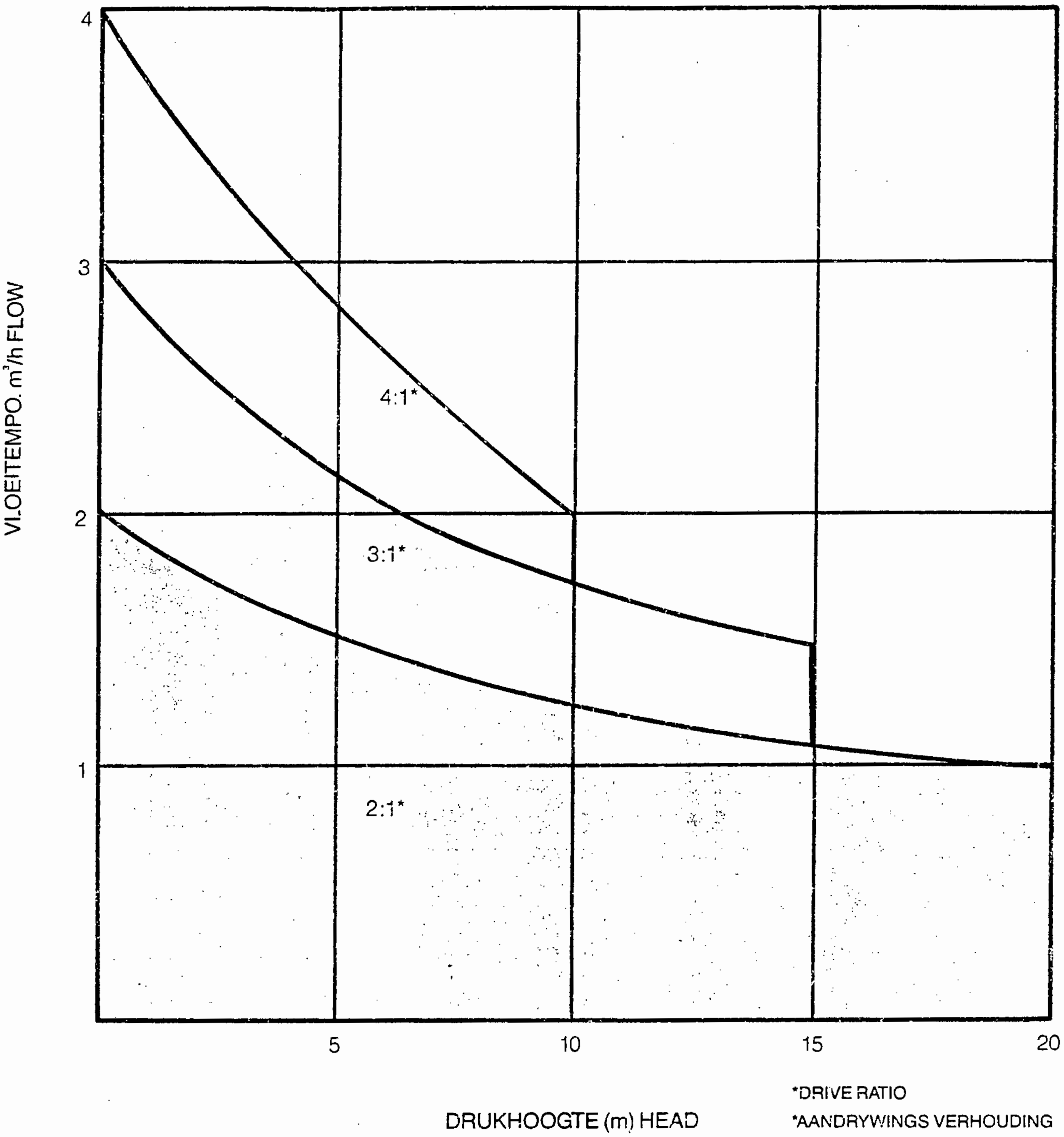
Eienskappe

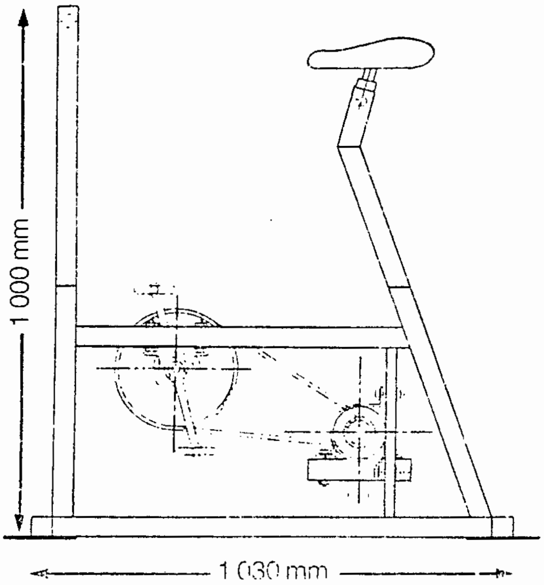
1. Verstelbare sitplek om almal te pas.
2. Sterk kettingaandrywing — saamgestel uit maklik bekombare komponente.
3. Veilig — alle bewegende dele is behoorlik toe en beskerm.
4. Drie ratverhoudings vir verskillende drukhoogtes.
   2:1 — 20 meter
   3:1 — 15 meter
   4:1 — 10 meter
5. Beproefde Mono-pomp positiewe verplasings element.
6. Inherent selfontlugtend.

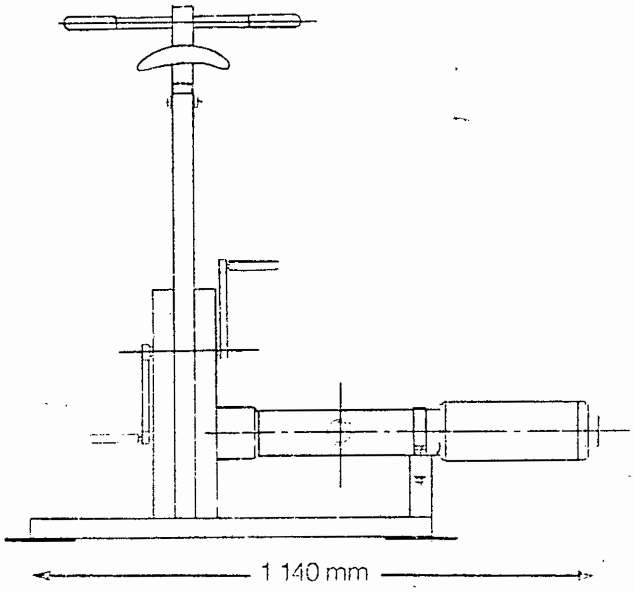


Typical average performance guide
(Average Pump Speed: 60r/min on the pedals)

Tipiese gemiddelde prestasiegids
(Gemiddelde Pomp Spoed: 60r/min op die pedale)







Appendix 2: Windpumps.

Climax
Climax-windpompe (Edms) Bpk.
Climax Windmills (Pty) Ltd.
✉ 20244, Peacehaven 1934, Vereeniging, Tvl. Suid-Afrika/South Africa, ☏ 54-20066, ☎ (016) 45133

Windpompe/Windmills
Nrs./Nos. 8, 10, 12, 14

Climax-windpompe laat waai

Climax leaves the rest standing still

Climax

Las-tabelle/Load Tables

Nr. 8 Climax-windpomp/No. 8 Climax Windmill

Wind -snelheid/speed km/h Maks.d'hoogte/Max. head m. Stygleiding/Rising Main mm		10/16 55/110 32 × 12	10/16 43/106 32 × 12	10/16 34/86 40 × 12	10/16 22/56 40 × 12	10/16 16/40 40 × 12	10/16 11/30 50 × 12	10/16 9/23 50 × 12	10/16 7/18 65 × 12	10/16 6/15 65 × 12
Liter/h Litres/h	2·7 m/s 10km/h 16km/h 4·4 m/s	72 126	100 162	130 204	210 330	288 462	390 624	540 840	660 1080	780 1260
Sil. diam./Cyl. diam. mm		40	45	51	65	76	90	102	115	125

Nr. 10 Climax-windpomp/No. 10 Climax Windmill

Wind -snelheid/speed km/h Maks.d'hoogte/Max. head m. Stygleiding/Rising Main mm		10/16 77/110 32 × 12	10/16 57/110 32 × 12	10/16 46/110 40 × 12	10/16 30/78 40 × 12	10/16 22/54 40 × 12	10/16 16/40 50 × 12	10/16 12/32 50 × 12	10/16 9/25 65 × 12	10/16 8/20 65 × 12
Liter/h Litres/h	10km/h 16km/h	84 156	117 200	150 246	246 460	330 540	450 720	650 960	780 1200	900 1460
Sil. diam./Cyl. diam. mm		40	45	51	65	76	90	102	115	125

Nr. 12 Climax-windpomp/No. 12 Climax Windmill

Wind -snelheid/speed km/h Maks.d'hoogte/Max. head m. Stygleiding/Rising Main mm		10/16 92/110 32 × 12	10/16 70/110 32 × 12	10/16 55/110 40 × 12	10/16 37/92 40 × 12	10/16 26/66 40 × 12	10/16 20/48 50 × 12	10/16 14/38 50 × 12	10/16 12/30 65 × 12	10/16 10/24 65 × 12
Liter/h Litres/h	10km/h 16km/h	96 170	132 240	174 300	264 430	375 600	510 830	708 1320	840 1620	1020 1680
Sil. diam./Cyl. diam. mm		40	45	51	65	76	90	102	115	125

Nr. 14 Climax-windpomp/No. 14 Climax Windmill

Wind -snelheid/speed km/h Maks.d'hoogte/Max. head m. Stygleiding/Rising Main mm		10/16 121/110 40 × 16	10/16 96/110 40 × 16	10/16 82/110 40 × 16	10/16 56/110 50 × 16	10/16 40/108 50 × 16	10/16 30/78 50 × 16	10/16 24/60 50 × 16	10/16 18/48 65 × 16	10/16 14/38 65 × 16
Liter/h Litres/h	10km/h 16km/h	80 156	105 210	150 270	230 400	325 520	450 720	570 960	730 1170	960 1500
Sil. diam./Cyl diam. mm		40	45	51	65	76	90	102	115	125

N.B.: Die syfers in die tabelle hierbó is gebaseer op 'n begin-windsnelheid van 10 en 16 km/h met gebalanseerde pompstange. Raadpleeg die Climax-werkverrigtingskurwe vir ander vereistes.

N.B.: The figures given in the tables above are based upon a start windspeed of 10 and 16 km/h and balanced pump rods. For operating performance outside of this assumption, refer to Climax's performance curves.

The S+L No. 18 windmill

1. The No. 18 Windmill is an open type, direct acting, 152 mm stroke mill with 5,5 m diameter windwheel.
2. No lubrication is required as all bearings are sealed for life ball bearings or self lubricating P.T.F.E. bushes.
3. The main frame is a rigid grey iron casting.
4. The head is supported by a P.T.F.E. bush and thrust washer in the tower cap and a P.T.F.E. bush in the lower guide.
5. The windshaft is of high tensile steel revolving in two sealed for life ball bearings with extra steel sealing plates to protect the front bearing from ingress of dust.
6. The crank is of S.G. iron and is keyed and pressed onto the windshaft for extra rigidity.
7. The connecting rod is a rigid grey iron casting fitted with a totally enclosed sealed for life ball bearing at the big end, and two P.T.F.E. bushes at the small end.
8. The windwheel is of all steel construction with eight spokes and three rims for rigidity. Every part is hot-dipped galvanised.
9. The tail carrier is of all-welded tubular construction, hot-dip galvanised after fabrication and fitted with a robust hinge arrangement to simplify erection. The tail vane, of heavy gauge galvanised steel sheet, is securely bolted to the tail carrier.
10. The tower is of four post design and built of heavy rolled steel angle iron, suitably braced and hot-dip galvanised throughout.

Die S+L Nr. 18-windpomp

1. Die Nr. 18-windpomp is 'n oop tipe, regstreekse windpomp met 'n werkslag van 152 mm en 'n windwiel waarvan die diameter 5,5 m is.
2. Dit vereis geen smering nie want al die laers is koeëllaers wat lewenslank verseël, of die busse selfsmerende PTFE-busse is.
3. Die hoofraam is 'n stewige grysystergietstuk.
4. Die kop word gesteun deur 'n PTFE-bus en -drukwaster in die toringdop en 'n PTFE-bus in die onderste leier.
5. Die windas is van hoëtreksterktestaal wat draai in twee koeëllaers wat lewenslank verseël is en wat ekstra staalseëlplate het om die voorlaers teen die indringing van stof te beskerm.
6. Die kruk is van SG-yster en word vasgespy en vir ekstra stewigheid aan die windas gedruk.
7. Die verbindstang is 'n stewige grysystergietstuk wat aan die groot ent toegerus is met 'n geheel ingeslote koeëllaer wat lewenslank verseël is, en aan die klein ent twee PTFE-busse het.
8. Die windwiel is heeltemal van staal vervaardig en het agt speke en drie vellings vir stewigheid. Elke onderdeel is deurgaans warmgegalvaniseer.
9. Die stertdraer is 'n sweispypkonstruksie wat na vervaardiging warmgegalvaniseer is en met 'n stewige skarnierstelsel toegerus is om oprigting te vereenvoudig. Die stertwiek wat van dik gegalvaniseerde staalplaat vervaardig is, is stewig aan die stertdraer vasgebout.
10. Die toring is van die vierstylontwerp en gebou van dik hoekyster van gewalste staal wat behoorlik verspan en deurgaans warmgegalvaniseer is.

No. 18 windmill load tables
Bucket rod loading – 550 kg
Stroke 152 mm

10% allowance for slip

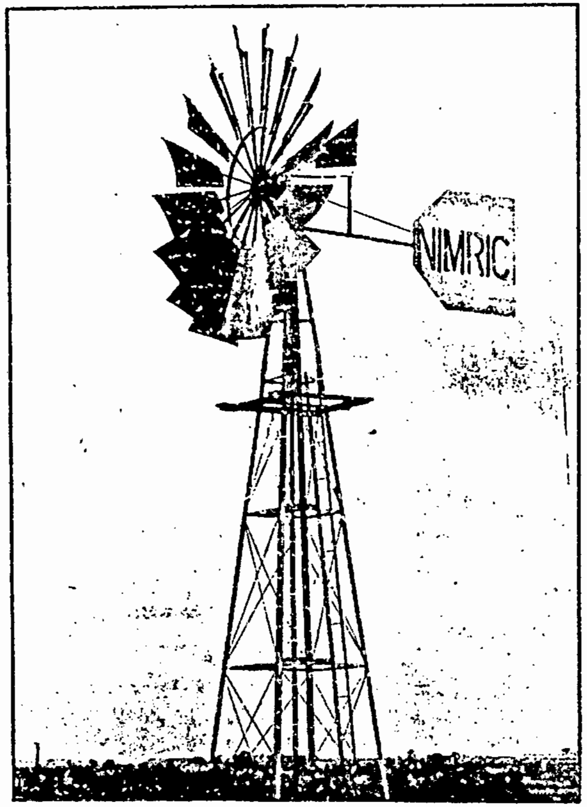
Lastabelle vir Nr. 18-windpomp
Pompstangbelasting – 550 kg
Slag 152 mm

10% toelating vir gly

Cylinder Silinder mm	m Surface pumping Oppervlakpompwerk	m Deepwell pumping Diepputpompwerk	38 S.P.M. l/hr – l/uur	55 S.P.M. l/hr – l/uur
51	269	168	623	931
57	213	144	786	1 145
65	182	124	972	1 422
70	142	108	1 181	1 727
76	120	94	1 408	2 072
83	102	83	1 636	2 417
90	91	73	1 908	2 794
102	67	58	2 499	3 681
108	60	52	2 817	4 158
115	53	47	3 135	4 635
127	43	39	3 908	5 725
152	30	28	5 635	8 225

NIMRIC

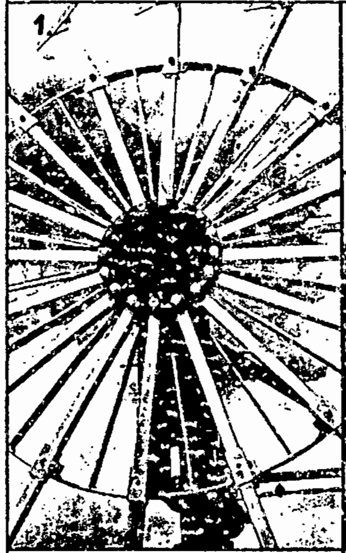
Low Maintenance Nimric Windmills



The Nimric Shortstroke Windmill

Advantages:

1. The Nimric Windmill is the cheapest Windmill in its class.
2. Very few moving parts.
3. Minimum lubrication required.
4. All spare parts obtainable from most CO-OP's or Hardware stores.
5. Erection very simple and convenient.
6. The weight of the Windmill head is far less than the conventional type, and can be lifted by one man.
7. Blades on the wheel can be individually inserted into their own space by only two bolts. (Fig. 1)
8. Very easily adjusted storm tail to swing out of strong winds. (Thus no brake necessary). (Fig. 2)
9. All rotating parts rotate on sealed ball bearings (factory lubricated). No gears or oil bath. (Fig. 3)
10. The most important feature of a Windmill is a shockabsorber on the main up and down rod -- this feature is built-in to the NIMRIC WINDMILL as it lengthens the life of the rods in the pipes as well as the bearings in the working head. (Fig. 4)
11. The wheel is very strong and efficient with up to 25 % more area in the wind than a normal wheel, with the same diameter — thus giving more power with less wind.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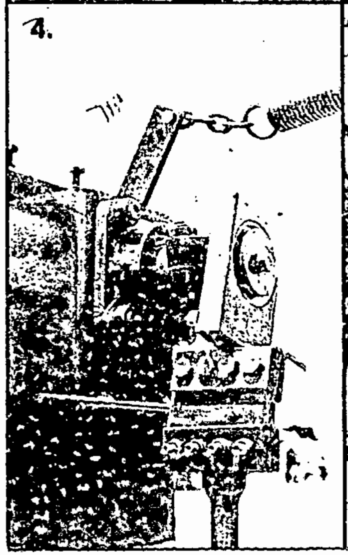
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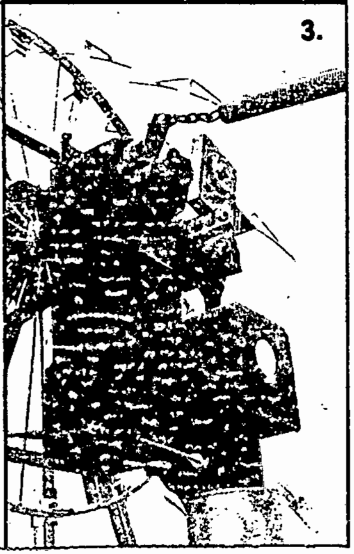

3.

NIMRIC WINDMILL CAPACITIES

WHEEL SIZES		CYLINDER DIAMETERS 45 mm (1¾")	50 mm (2")	63 mm (2½")	75 mm (3")	90 mm (3½")	100 mm (4")	106 mm (4½")	125 mm (5")	150 mm (6")
2,45 m (N° 8)	Total lift in metres	40	33	23	17	13	11	9	7	5
	Average litre per day	4000	5145	8100	11600	16200	20700	26100	32400	46800
3 m (N° 10)	Total lift in metres	72	60	43	32	25	10	16	13	10
	Average litre per day	4000	5400	7875	11340	15435	20250	25650	31500	45450
3,66 m (N° 12)	Total lift in metres	96	80	58	43	33	26	19	17	13
	Average litre per day	4275	5600	8550	12375	16875	19400	27540	34200	49500
4,3 m (N° 14)	Total lift in metres	130	112	82	60	55	43	32	25	18
	Average litre per day	4100	5750	8700	12420	17100	21400	29600	36000	54200

Southern Cross

SENESCHAL PATROON
DIREKTE AKSIE
WINDPOMPE

DIE "ROLLS-ROYCE" VAN WINDPOMPE ...VIR DIE MEES VEELEISENDE WERK

Met die vervaardiging van die "Seneschal" het Suiderkruis 'n windpomp gemaak van hoër ingenieurstandaarde as wat ooit tevore toegepas is in die vervaardiging van Windpompe.

Modern, doeltreffend en betroubaar. Die aantal wat opgerig is deur grondeienaars en regeringsdepartemente by veestasies, veepaaie, plase en vir dorpsvoorsiening en veral in afgeleë plekke soos in die Kalahari waar hulle enjin-pomptoestelle vervang, getuig van hul betroubaarheid om goeie watervoorrade te lewer.

Die "Seneschal" word gemaak vir groter pompwerke, soos water uit diep boorgate te pomp en ook om water oor lang afstande te pomp.

- KRAGTIGE WINDWIEL
- OUTOMATIESE SMERING
- GLADDE DRAAITAFEL
- ALGEHELE OMHULSEL
- WETENSKAPLIK ONTWERPTE SKEPPERS

UITEENGESETTE SPESIFIKASIE

MOEITEVRYE OUTOMATIESE SMERING. Die smeerstelsel van die Seneschal-windpomp verseker goeie smering van alle werkende dele van die windpomp *sonder dat dit nodig is om op die toring te klim*. 'n Oliehandpomp word aan die toring naby grondvlak gemonteer en olie kan van die pomp na die enjin van die windpomp gepomp word. Olie kan dus vervang word *sonder om op die toring te klim*. Geen ander windpomp het so 'n maklike outomatiese oliestelsel nie.

ALGEHELE OMHULSEL BESKERM ENJIN. Die enjin van die pomp is heeltemal omhul, stof- en waterdig.

POSITIEF GEKOPPEL AAN WIELNAAF. Die wielnaaf word deeglik aan die as vasgesit deur middel van twee spye wat van teenoorgestelde rigtings ingedryf word en dan gesluit word. Sluitmoere word reghoekig aan die spye gepas.

MAKLIKE WERKING OPWAARTSE EN AFWAARTSE MEGANISME: Die krag van die windwiel word deur middel van die hoofas na die kruk en dryfstang gelei en na die dwarskop wat beweeg tussen V-seksiegleiers.

KRAGTIGE WINDWIEL. Die struktuur van die windwiel bestaan uit 'n stel Swaarbalkspeke wat dubbel aan die flense van die wielnaaf gebout word. Elke speek is 'n aparte aanmekaar-geklinkte eenheid, en wanneer die wiel aanmekaar gesit is, vorm dit 'n stewige eenheid waaraan die vlerke gebout word.

WETENSKAPLIKE ONTWERPTE VLERKE is gespesiaal gevorm en gebuig om die maksimum pompvermoë te verseker en dat die wiel maklik sal begin draai.

SENESCHAL PATTERN
DIRECT ACTION
WINDMILLS

THE "ROLLS-ROYCE" OF WINDMILLS ...FOR THE MOST EXACTING DUTY

With the production of the "Seneschal" Southern Cr built a Windmill to much higher engineering standa than ever previously employed in Windmill manufacture.

Modern, efficient and reliable, the numbers installed by Landowners and Government Departments on Stations, Stock Routes, Farms and for Town water supplies and particularly in such remote areas as the Kalahari where they have replaced many engine pumping plants, testify to their dependability in maintaining reliable water supplies.

The "Seneschal" is made for the bigger pumping jobs, such as for pumping big quantities of water from deep bores and for pumping water over long distances.

- POWERFUL WINDWHEEL
- AUTOMATIC OILING
- FREE PIVOTING TURNTABLE
- COMPLETELY ENCLOSED
- SCIENTIFICALLY DESIGNED FANS

SPECIFICATION

TROUBLE-FREE AUTOMATIC OILING. The lubricating system of the Seneschal windmill thoroughly oils all its working parts of the windmill *without the necessity of climbing the tower*. A hand pump is fitted near the ground and oil is pumped from there to the mill engine so the oil can be replenished, *without climbing the tower*. No other windmill has such a positive automatic oiling system.

COMPLETE ENCLOSURE PROTECTS ENGINE. The mill engine is totally enclosed, dust and weather proof

POSITIVELY FASTENED WHEEL HUB. The wheel hub casting is securely fastened to the main shaft with two gib head keys driven home in opposite directions and then locked. Locking screws are also fitted at right angles to the keys.

EASY WORKING RECIPROCATING MECHANISM. The power from the windwheel is transmitted from the main shaft through the crank and connecting rod to a crosshead which runs between adjustable V-section guides.

POWER WINDWHEEL. The windwheel structure comprises a set of cantilever girder wheel arms double bolted to the flanges of the wheel hub. Each wheel arm is separate riveted unit and the wheel arms are connected to provide a very rigid framework into which the sails are bolted.

SCIENTIFICALLY DESIGNED SAILS are specially shaped and curved so as to combine maximum pumping efficiency with easy starting.

SIZE MILL		44 mm	51 mm	57 mm	64 mm	70 mm	76 mm	83 mm	90 mm	102 mm	108 mm	115 mm	127 mm	153 mm	203 mm	254 mm	305 mm
5,2m "RF" 176mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meters Avg. Litre/Day/Gem. Liter/dag	146 5900	126 6200	110 10500	95 12700	84 15500	73 18000	62 [illegible]	53 25100	41 33200	37 37200	32 41600	26 [illegible]	18 74000	10 132000		
5,2m "RF" 203mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meters Avg. Litre/Day/Gem. Liter/Dag	128 7300	110 9500	94 11700	82 14500	73 17700	64 21400	55 [illegible]	47 25100	37 37700	32 42700	29 47700	23 54100	16 85000	[illegible] 151000	– 	
6,5m "RG" 210mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meter Avg. Litre/Day/Gem. Liter/Dag	– –	- -	175 10000	152 12300	134 15000	119 17700	105 21000	94 24100	73 31400	64 [illegible]	58 40000	47 [illegible]	37 71000	18 136000	12 197000	9 262000
6,3m "RG" 254mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meter Avg. Litre/Day/Gem. Liter/Dag	– -	 -	143 12300	125 15000	110 15700	93 21400	82 25000	76 29100	61 38200	53 43200	47 48200	[illegible] 59000	27 86000	15 153000	10 238000	7 342000
7,5m "RH" 241mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meter Avg. Litre/Day/Gem. Liter/Dag		-		216 11500	194 14500	175 17300	157 [illegible]	140 23200	107 30500	94 34500	85 38600	60 [illegible]	41 65000	27 122000	17 190000	12 274000
7,5m "RH" 305mm Stroke/ Slaglengte	Total lift in Metres/Totale hoogte in meter Avg. Litre/Day/Gem. Liter/Dag	- -	- –		162 15000	145 15200	130 21800	117 [illegible]	107 29500	85 38000	75 43200	67 48000	55 [illegible]	38 80000	21 154000	14 240000	9 345000

FOR POWER FOR WATER
VIR KRAG VIR WATER

[illegible]

CLIMAX Rotary Drive Windmill

INTRODUCTION

Due to the need for larger capacity wind machines, Climax designed and embarked upon a test program lasting several years, with rotary drive windmills.

These mills deliver more water under certain conditions than conventional mills, and are designed to give many years of troublefree service.

Since the last century, Climax has proven their product by making more than 200 000 windmills a part of the Southern African landscape. This success can be attributed to the Climax policy of QUALITY AND DURABILITY.

Due to the power and speed required to drive rotary screw pumps, it was decided to begin the research on the larger diameter wheels. Extensive factory tests and field trials have proven this right and the initial launch onto the market was with the No. 15, with a 4,57m diameter wheel and the No. 18 with a 5,46m diameter wheel.

OUTSTANDING FEATURES

1. **GEARS**
   The 1:10 gear ratio is achieved with a double set of robust machined gears, which minimise wear and give many years of smooth running performance.
2. **OILBATH**
   The spurgear is partially submerged in a 5ℓ oilbath which splash lubricates the bevel gear and pinion. All bearings are of the durable sealed for life, deep grooved ball type.
3. **OIL SEALS**
   The gearbox was specifically designed to exclude the use of oil seals.
4. **RATCHET**
   The final drive bevel pinion incorporates a simple spring-loaded ratchet which allows the drive rods to stand stationary when the wheel is turned backwards. This ensures that drive rods are not unscrewed.
5. **FURLING MECHANISM**
   To safeguard against damage in gale force and gusty wind conditions, this design incorporates the furling mechanism proven for more than 80 years on our conventional reciprocating windmills. (See sketch on last page.)
6. **DETACHABLE MAST TUBE**
   Due to this feature, a shorter Gin Pole can be utilized, saving valuable erection time.
7. **DRIVE RODS AND COUPLING**
   The drive rods running from the windmill head to the borehole pump are guided by sealed for life flanged bearings, mounted to brackets clamped to the tower construction. A quick release coupling allows the disconnected borehole pump to be driven by exterior power sources.
8. **WHEEL**
   Due to the design of the gearbox, it was necessary to slightly dish the wheel to clear the tower. This was done without affecting the efficiency of the standard wheel which has proven itself over many years of service.
9. **MAINTENANCE**
   It was inevitable that in any machine, parts will eventually have to be replaced. For this reason a lot of thought was given to the replacement of parts without removing the head from the tower.

TECHNICAL SPECIFICATIONS

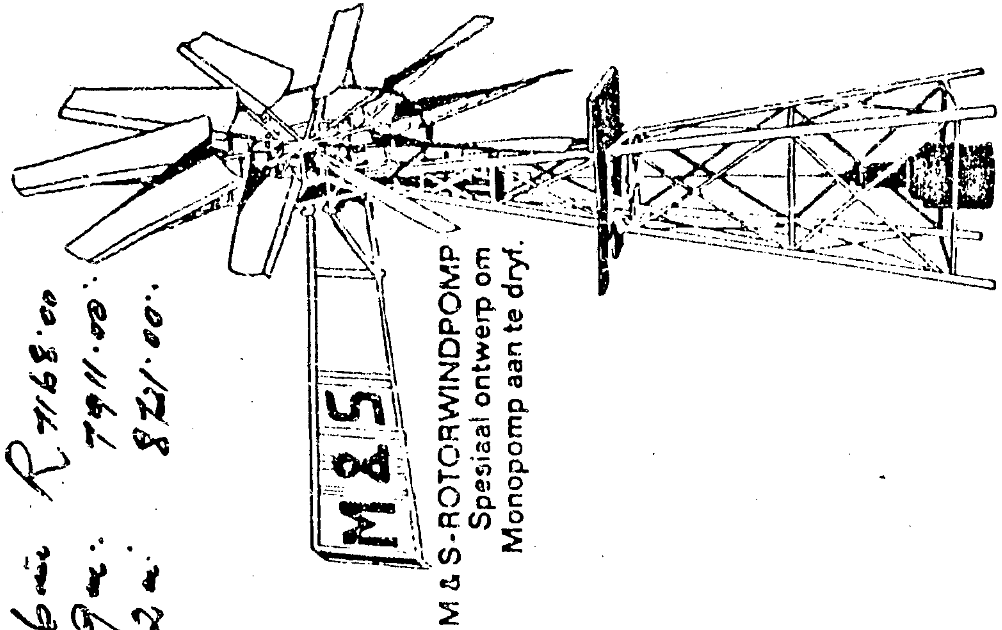
Gear Ratio	No.15 No.18	1:10 1:10
Oil Capacity	No.15 No.18	5ℓ 5ℓ
Maximum Pump R.P.M.	No 15 No.18	700 R.P.M. 500 R.P.M.
Maximum Windwheel Power Output	No.15 No.18	8,8 kw 12,75 kw
Mass of Gearbox	No.15 No.18	169 kg 185 kg
Mass of Windmill Head complete	No.15 No.18	645 kg 949 kg
Furling windspeed	No.15 No.18	± 55 km/h ± 45 km/h
Wheel Diameter	No.15 No.18	4,57 metres 5,48 metres
Performance	No.15-600 L/p.h. - 18000 L/p.h. Head up to 150 M. No.18-400 L/p.h. - 24000 L/p.h. Head up to 180 M	

REED PRINT S/L 855

DIE M. & S.
ROTOR WINDPOMP

R.S.A. Patent Nr. 77/7269
77/3303
S.W.A. Patent Nr. 79/0137

6 vt: R7168.00
9 vt: 7911.00
12 vt: 8721.00



M & S-ROTORWINDPOMP
Spesiaal ontwerp om
Monopomp aan te dryf.

Vervaardig deur:
Midkaap Ingenieurswerke
(Edms.) Bpk.

Posbus 43
Telefoon 0483-21051
MIDDELBURG, KAAP
5900

M. & S. ROTOR LEWERINGSTABEL

MONOPOMP MODEL	GROOTTE	KOPHOOGTE IN METER	O.P.M. 550 WINDSPOED 20 KM L.P.U.	O.P.M. 400 WINDSPOED 12,8 KM L.P.U.	O.P.M. 260 WINDSPOED 8,6 KM L.P.U.
ES 10 D	40 mm	198	787	572	372
ES 15 D	40 mm	198	1 437	1 044	678
ES 30	50 mm	137	3 365	2 443	1 588
ES 50	50 mm	122	4 930	3 580	2 327
BH 100	50 mm	76	7 204	5 232	3 400
BH 150	65 mm	45	13 312	9 668	6 284
BH 200	80 mm	30	22 160	16 096	10 462
BH 250	80 mm	20	34 200	24 838	16 820
BH 300	80 mm	15	43 000	31 227	20 298
BH 350	80 mm	15	57 300	41 603	27 040

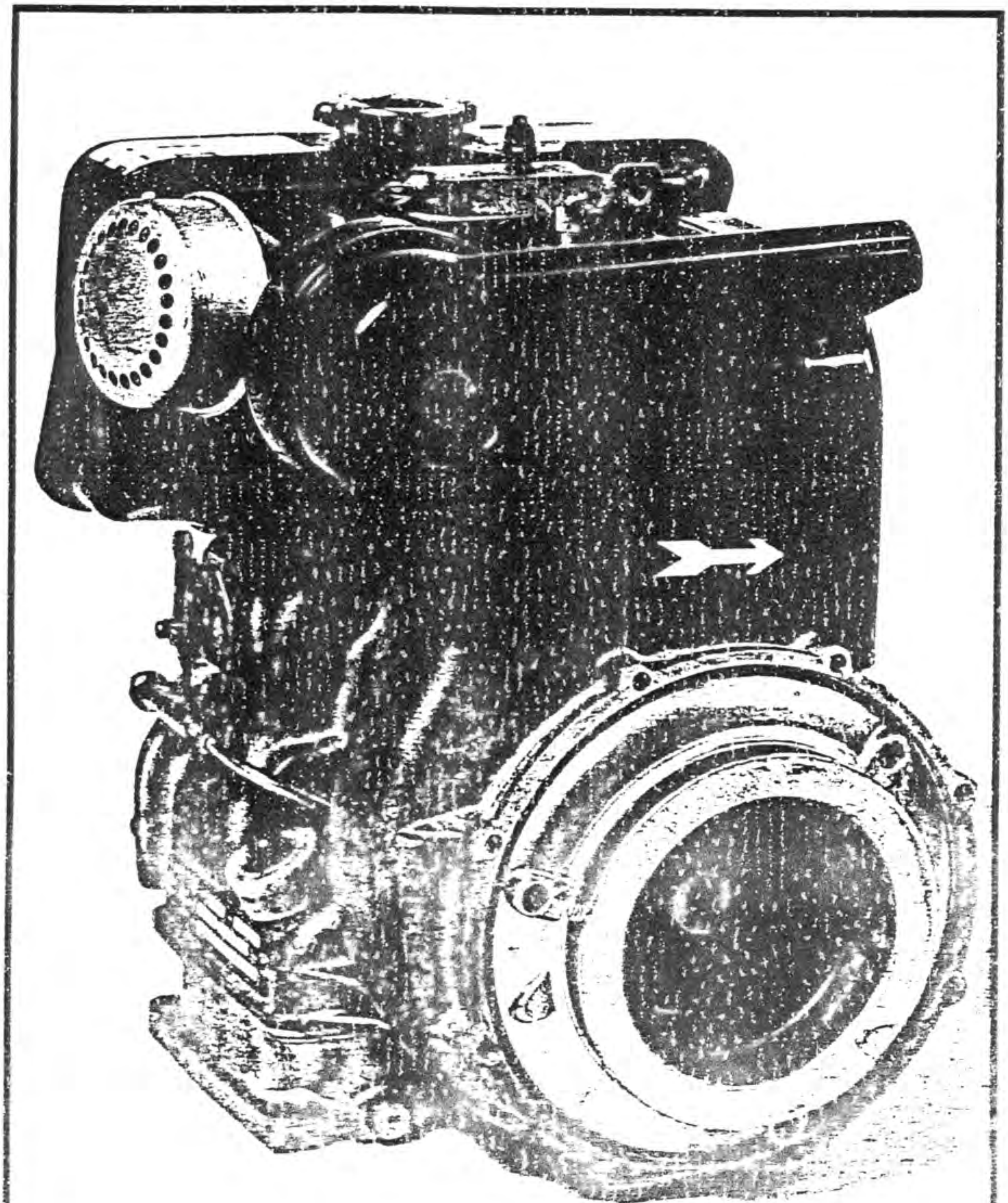
Appendix 3: Diesel Pumps.

Petter

'A' RANGE
1,2–4,8 kW

LIGHTWEIGHT AIR COOLED DIESEL ENGINES

LIGGEWIG LUGVERKOELDE DIESELENJINS



MANUFACTURED IN SOUTH AFRICA BY: ◆ VERVAARDIG IN SUID-AFRIKA DEUR:

Salister Diesels

Specifications

The Petter 'A' Range of engines are all single cylinder, four stroke, overhead valve, air cell system, air cooled compression ignition engines.
This highly successful range of diesels are made of lightweight alloys within compact dimensions. It has been designed to combine easy starting with minimum maintenance and long service life.

Spesifikasies

Die Petter 'A'-reeks enjins is almal enkelsilinder-, vierslag-, kopklep-, lugsel-stelsel-, lugverkoelde drukontstekingenjins.
Hierdie besonder suksesvolle dieselreeks word uit liggewig allooie in kompakte vorm vervaardig. Die ontwerp kombineer maklike aansit met die minimum instandhouding en 'n langdienslewe.

Engine Power Ratings

Kraglewering

ENGINE SPEED ENJINSPOED	CONTINUOUS kW DEURLOPEND				
r/min	AAI	ABI	ACI	ACIZ	ACIZS
1000	–	–	–	–	1,15
1500	1,15	–	2,0	1,7	1,85
1800	1,35	2,0	2,45	2,45	2,25
2100	1,55	2,4	3,0	3,0	–
2500	1,85	2,85	3,7	3,7	–
3000	2,25	3,35	4,45	4,45	–
3600	2,60	3,7	4,8	–	–

Technical data

Tegniese gegewens

MODEL		AAI	ABI	ACI	ACIZ	ACIZS
Bore/Boor	mm	69,8	76,2	76,2	76,2	76,2
Stroke/Slag	mm	57,15	57,15	66,67	66,67	66,67
Cubic capacity/Kubieke kapasiteit	Litres/Liter	0,219	0,261	0,304	0,304	0,304
Lub. oil capacity/Smeerolie-kapasiteit	Litres/Liter	1,9	1,9	2,8	2,8	2,7
Mass/Massa	kg	43	45	47	48	63,5

Rated Power

All powers quoted apply to run in engines fitted with air cooling fan, lubricating oil pump, air cleaner and exhaust silencer in accordance with BS 5514/1 (ISO 3046/I). All engines are tested in accordance with BS 5514/2 (ISO 3046/II) Engine Group No. 2. Continuous Power is equivalent to ISO Standard Power. Overload Power is 110% of Continuous Power and available for 1 hour in any 6 hour period of variable load operation, depending on the application.

Aangeslane krag

Alle leweringsvermoëns het betrekking op enjins toegerus met lugverkoelingswaaier, smeeroliepomp, lugsuiweraar en uitlaatdemper volgens BS 5514/1 (ISO 3046/I). Alle enjins word getoets volgens BS 5514/2 (ISO 3046/II). Enjingroep No. 2. Volgehoue krag is gelykstaande aan ISO-standaardkrag. Oorbelading is 110% van Volgehoue Krag en is 1 uur lank uit enige wisselbare vragwerkingsperiode van 6 uur beskikbaar, afhangende waarvoor dit benodig word.

Derating

For non-standard site conditions engine power should be adjusted in accordance with BS 5514/1 (ISO 3046/I). For accurate values of derating consult Salister Diesels.
Approximate site service power can be obtained by using the following correction factors:
Altitude: 6 ½ % per 500 m above 150 m.
Temperature: 3% per 10°C above 27°C.

Laer aanslag

In nie-standaard-terreinomstandighede behoort die enjinkrag volgens BS 5514/1 (ISO 3046/I) aangepas te word. Om die akkurate waardes vir laer aanslaning vas te stel, pleeg oorleg met Salister Diesels. Die terreindienskrag kan min of meer bepaal word deur die volgende korreksie-faktore in ag te neem:
Hoogte bo seespieël: 6 ½ % per 500 m bo 150 m.
Temperatuur: 3% per 10°C bo 27°C.

Governing

For general purposes the governing conforms to BS 5514/4 (ISO 3046/IV) Class B1, based on a design speed of 3600 r/min. For fixed speeds of 3000 and 3600 r/min normal governing accuracy to class A2 is obtained.

Reëling

Vir algemene verbruik is die reëling volgens BS 5514/4 (ISO 3046/IV) Klas B1 gestel, gebaseer op 'n ontwerpspoed van 3 600 r/min. Teen 'n vaste spoed van 3 000 en 3 600 r/min word normale reëlingsakkuraatheid in Klas A2 behaal.

Appendix 4: Solar Pumps.

MSP-103 Solar Cell Module

HIGH-QUALITY, HIGH-PERFORMANCE SOLAR CELL MODU

Highly pure silicon crystals of MSP-103 are product of the most stabilized method, offering unrivaled quality and performance.

Extraordinary Durability under the Severest Outdoor Conditions

MSP-103 package made from tempered white glass, resin, and special films is a highly reputed achievement of out packaging technology with longtime history. This unique packaging method guarantees superb durability under all imaginable stringentest conditions.

High Electric Conversion Efficiency

A special anti-reflection film covering the solar cell front surface and Back Surface Field structure, plus the high purity silicon. All these contribute to attaining the 16.4% or more cell conversion efficiency and module efficiency as high as 12.0%

Lightweight

Use of lightweight aluminum and resin drastically reduced the weight of module.
This means simplified and easy transport and installation.

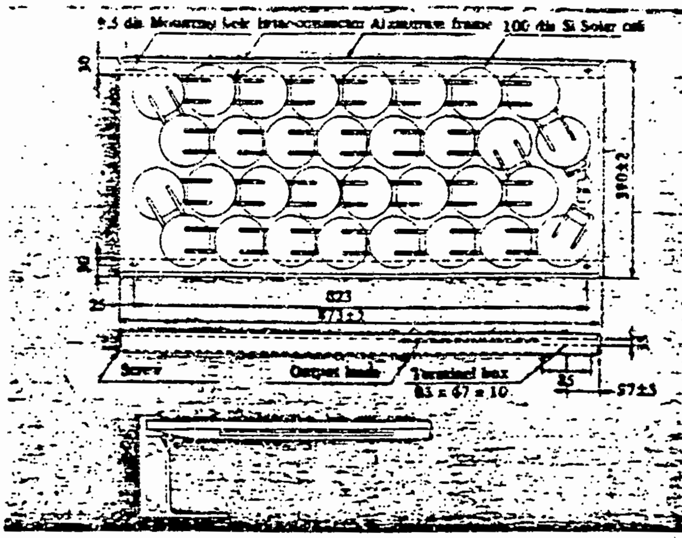


Fig. 1 MSP-103
Current, Power vs. Voltage Characteristics

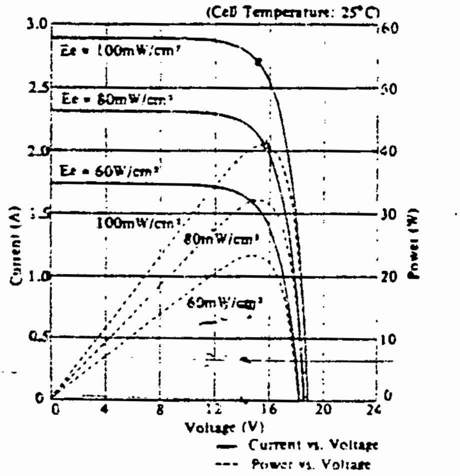


Fig. 2 MSP-103
Open Circuit Voltage, Short Circuit Current vs. Irradiance

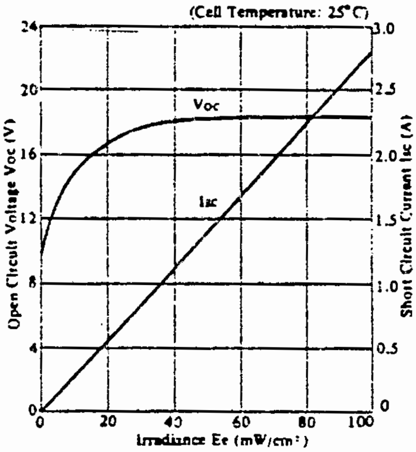
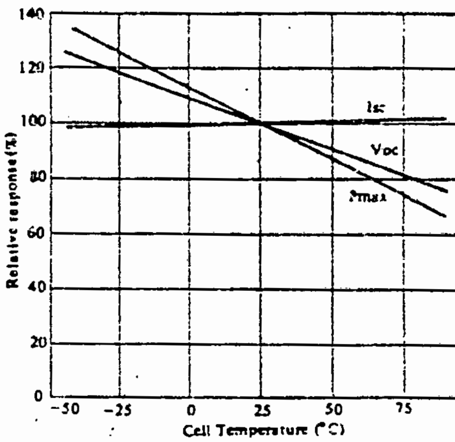


Fig. 3
Temperature Characteristics



Specifications

Element size	100mm dia silicon cell
No. of element	32
Voltage	DC 12V systems
Power output	41W
Dimensions	873(W) x 390(H) x 35(D) mm
Weight	4.7kg

Absolute maximum ratings

Ratings	Symbol	Value	Units
Operating temperature	Topr	−40 ~ +90	°C
Storage temperature	Tstg	−40 ~ +90	°C

Electro-optical characteristics

(Cell temperature :

Characteristics	Symbol	Type	Units	Conditions
Open-circuit voltage	Voc	19.0	V	Ee = 100mW/
Optimum operating voltage	Vop	15.3	V	
Short-circuit current	Isc	2.89	A	
Optimum operating current	Iop	2.68	A	
Maximum power output	Pmax	41	W	
Conversion efficiency	η	16.4	%	

*Ee : Irradiance from the sun at sea level

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REPORT NO. GEN 128

A GUIDE TO TECHNOLOGY SELECTION AND PLANNING FOR VILLAGE WATER SUPPLIES UTILISING GROUNDWATER AND SPRING WATER SOURCES

FINAL REPORT

K WISEMAN MAY 1989

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