TECHNICAL HANDBOOK No. 23

WATER FROM SAND RIVERS

A manual on site survey, design, construction and maintenance of seven types of water structures in riverbeds

Erik Nissen-Petersen

RELMA

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Top: Storm water flowing through a seasonal river
middle: Community participation in the construction of a sand dam
Bottom: A sand dam constructed across a seasonal riverbed

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PREFACE

This manual is intended for technicians, builders, trainers, students and development agencies dealing with site survey, design, construction and maintenance of:

- Hand-dug wells in deep sand,
- River-intakes with shaft in riverbank,
- Intake chambers with elevated water tank,
- Subsurface dams built of soil,
- Subsurface dams built of rubble stone masonry and
- Sand dams built of rubble stone masonry.

The manual is the first of a series of manuals covering:

- Water from sand rivers,
- Water from rock outcrops,
- Water from roads and compounds,
- Water from ponds and earth dams and
- Water from roofs.

The aim of these manuals is to present technical data on the development of affordable water sources in a comprehensive form which can be understood and applied by both designers and builders alike.

The structures described have a few things in common; they are built using simple techniques and are cheaper to construct and maintain than conventional water supply systems such as boreholes and reticulated piped water supply systems.

The manuals are based on 25 years of experience with practical work on designing, constructing and repairing various types of water supply systems in Africa and Asia. A few of the structures described here were adapted from structures built almost a hundred years ago, while others were invented and tested within recent years.

As time goes on, new improvements will develop in construction techniques and cost-reducing procedures. Readers are kindly requested to share their experience with the author such that improvements can be included in future editions.

Åke Barklund
Director, RELMA

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Special thanks go to the hundreds of engineers, technicians and builders in several countries who have worked together with me on the development of sand rivers during the last 25 years.

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TECHNICAL TERMS USED IN THE MANUAL

ASALCON	ASAL Consultants Ltd.
BQ	Bill of Quantity.
Catchment	An area draining rainwater.
Draw-off pipe	Pipe extracting water from a reservoir.
Underground dyke	River floor protruding upwards.
Flash-floods	Flooding by rainwater run-off.
Infiltration pipe	Pipe through which water infiltrate.
Key	An underground extension preventing seepage.
Maximum flood level	The highest water level during floods.
River banks	The two sides of a sand river.
Riverbed	The area between the river banks.
River floor	The base under the sand in a riverbed.
Run-off	Rainwater running off a surface.
Spillway	Overflow for surplus water from a dam.
Subsurface	Below the surface.
Throw-back	Length of a water reservoir from dam wall.
Wing-walls	Extensions of a dam wall into riverbanks.

FINANCIAL TERMS USED IN THE MANUAL

Ksh	Kenyan Shillings.
Ksh 70/US$ 1.00	
Value of community work	depends on local cost of labour and materials.

INTRODUCTION

1.1 What is a sand river ?

Definition of sand rivers

Sand rivers, also called dry riverbeds, luggas or wadis, are ephemeral (seasonal) watercourses containing sand, which are flooded with rainwater run-off from higher elevated catchment areas once or a few times in a year.

Plate 1: *A sand river*

1.2 History of sand river development

Water has been extracted from waterholes in sand rivers from time immemorial. The damming of water in sand rivers took place in Sardinia and North Africa some 2,000 years ago and in Arizona in the 1700s (Nilsson. 1988).

Subsurface dams built of soil were constructed by the Tanganyika Railway to provide water for their steam locomotives around 1900. The Bihawana Mission and others later replicated these near Dodoma in Tanzania. Sand dams were also built in Namibia, formerly known as South West Africa, by Wipplinger in the 1950s.

More than a hundred sand dams were built by various projects in Machakos and Kitui, with the most notable contributions being;

- Classen, of African Land Development (ALDEV) in the 1950s,
- Machakos Integrated Development Project (MIDP) in the 1980s funded by the European Economic Community
- Kitui ASAL programme in the 1980s, also built subsurface dams

- The Green Valley Project in the 1970s funded by Danida, Danish International Development Agency in Machakos, and
- Mutomo Soil & Water Conservation Project in the 1980s also funded by Danida.

Since 1990, the author has conducted many training courses on sand river development in Kenya, Tanzania and Burma.

The feasibility of constructing subsurface and sand dams in the semi-desert of Turkana in Kenya was studied by NORCONSULT in 1980. In the course of the year 2000, Mr. Eric Fewster and Dr. Frauke de Weijer built subsurface dams of soil on trial basis at Lockichogio and Lodwar respectively.

1.3 Benefits of extracting water from sand rivers

Storage and extraction of water from the voids between sand particles in sand rivers have the following benefits:

Evaporation

This is confined to the upper layer of sand reservoirs. As the water level sinks, evaporation is reduced accordingly and due to the lack of capillary action, stops when the water level sinks to about 60 cm below the sand surface. Reduced evaporation loss is a major advantage in hot and arid climates.

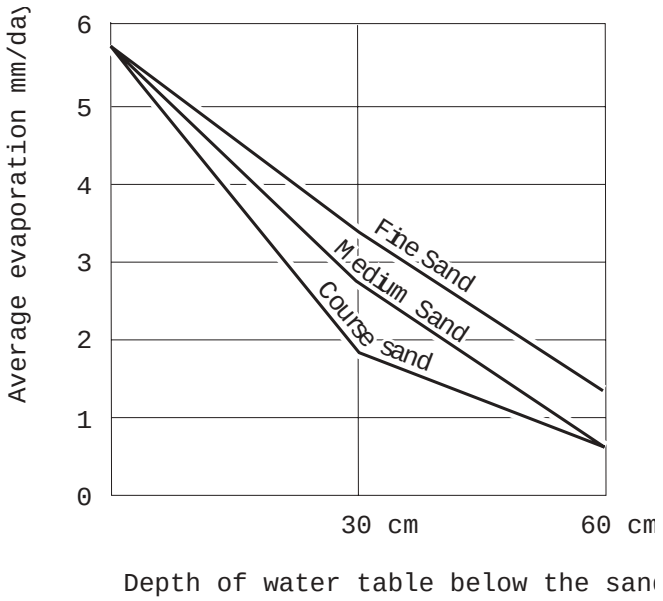

Figure 1: *Evaporation as a function of depth of water table.*

(Nilsson, 1988, quoting Hellwig, 1973).

This usually occurs only from sand reservoirs, which overlay fractured rocks or boulders. Such places should therefore be avoided when selecting new construction sites.

Siltation

Siltation does not create any problems because flash floods pass over sand reservoirs that are already full of sand. Topsoil particles and debris are cleared off during flooding. This is of particular benefit in eroded lands where open earth dams silt up quickly.

Contamination

Contamination of the water by insects, birds and animals cannot take place because the water is not exposed. Pollution by people and livestock can be avoided if water activities such as washing clothes or bathing take place on the downstream part of the dam wall, or on the riverbanks. Due to the lack of exposed water, mosquitoes cannot breed and spread malaria, bilharzia-carrying snails cannot survive and other water-borne diseases are also reduced dramatically.

Downstream flow of water

This is not affected because sand reservoirs are only recharged during floods, when water is plentiful everywhere. People living downstream will therefore not be deprived of water. The natural underground dyke would, in any case, also naturally hold the water from progressing downstream.

Recharge of sand reservoirs

This takes place when rains flood the sand river. Sand rivers with large or hard runoff catchments such as roads or rock outcrops, can produce sufficient runoff from about 10 mm of rain per hour to recharge water reservoirs in sand rivers.

1.4 Constraints and recommendations

Unfortunately, quite a number of sand dams have been built which are not functioning due to the wrong selection of construction sites, incorrect design or poor workmanship. The most economical approach to extract water from a sand river as explained in this manual, is to start with a minimum input of labour and materials while ensuring that the quantity and quality of water obtained is worth the investment.

However, not all types of sand rivers can be developed cost effectively to yield sufficient water. The sand rivers with the highest potential contain coarse sand, are flooded a few times every year, have a minimum width of sand of five metres and an average depth of sand of at least one metre.

Sand rivers with waterholes

In sand rivers with waterholes, which provide water for at least one month after the last flooding, the approach should be to start with building a hand-dug well in a riverbed (Plate 2) or a river-intake with a well shaft in a riverbank. Should the well or intake not supply sufficient water, the yield of water can be increased by building a subsurface dam of soil on an underground dyke downstream of the well or intake (Plate 3). Should this still not be sufficient, then the volume of the sand reservoir can be increased by building a subsurface dam of 50-cm height above the sand level with rubble masonry next to the subsurface dam built of soil (Plate 4). Should the yield still not be sufficient, then a sand dam can be built. It should be noted that this is the most difficult and expensive option for extracting water from sand (Plate 5).

Plate 2: *A hand-dug well with a hydrodynamic well head being build.*

Plate 3: *A community building their subsurface dam of soil.*

Plate 4: *A hand-dug well with a subsurface dam downstream.*

Plate 5: *Building a sand dam of rubble stone masonry.*

Sand rivers without waterholes

In sand rivers without waterholes, the approach is different because the reasons for the absence of waterholes may be that;

- the reservoir could leak due to fractured rocks or boulders draining water underground. Such leakage may benefit a nearby borehole.
- the floor under the sand is flat and lacking underground dykes, which can trap water and facilitate waterholes.

In both cases, the most practical and economical approach is to build a subsurface dam of soil and wait for floods to fill the sand reservoir with water. The yield of water can be monitored thereafter by digging a few waterholes. Should the waterholes dry up quickly after floods, then the sand reservoir is leaking and the site might have to be abandoned. If the yield is sufficient for a month or so, then it is possible to proceed as described in chapter 3.