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WATER, SANITATION, ENVIRONMENT and DEVELOPMENT

Earth dams for RWS in Northern Region

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Introduction

Rural water supply in Ghana, especially with the declaration of the International Drinking Water Supply and Sanitation Decade, has been characterised by the harnessing of groundwater for domestic and other uses. Groundwater has been exploited mainly by the use of hand dug wells and drilled bore-holes fitted with handpumps. An alternative water source being used for rural water supplies in a part of the Northern Region is surface run-off impoundment using earthdams and dug-outs.

Test drilling results and other hydrogeological conditions indicate water scarcity in the southern part of Northern Region which forms the Project area.

The area is underlain by the upper voltaian geologic formation and has these hydrogeological characteristics: (Figure 1).

1. Geologically, it is composed of impermeable rock consisting of hard sandstone and mudstones with shales (Norrip 1982). This formation does not allow effective surface water infiltration due to shallow weathering, clayey soils and lack of significant fracture patterns. Test holes show a 28% probability of success per hole(Tod, 1981).

2. Seasonal flow of streams and other surface water sources. There is a 6-month (October-April) dry period with a yearly and daily mean temperatures of 28°C and 12°C respectively. Evaporation is estimated at 1800mm for open water annually. Rainfall is relatively high during the rainy season varying from 1000 to 1300mm annually with estimated run off co-efficient of 10% of total rainfall (Tod, 1981).

These characteristics imply unreliability of both ground and surface water sources in the area.

Choice of water source

Physical and socio-economic factors influenced by the hydrogeological conditions mentioned above, underlie the choice and use of earthdams and dug-outs to impound surface run-off for water supply.

The physical factors are:

1. High surface run-off during rainy season.

2. Semi-impermeable soils and bedrock, and

3. Slightly rolling to flat landscape.

High water requirement for livestock and other economic activities in the area provide the socio-economic condition favouring the use of surface water impoundment.

Between 1988-1992, the Project has assisted in constructing 11 gravity-type earthdams and 6 dug-outs to serve approximately 33,000 people and 28,500 of livestock in their design year. Total investment cost during the period is about US $5 million. (Bouman, 1992). Examples of some of the constructions undertaken during the period are presented in Table 1.

Design and construction

In collaboration with the beneficiary community, a suitable site is selected for the dam. A condition for site selection is the need for a maximum walking distance not to exceed 1.5 kilometres from the settlement though topography and soil suitability primarily determines the site.

Topographical and soil surveys are followed by design and construction of the dam and other components. The choice between a gravity dam and dug-out for a selected site is influenced by water demand, topography and availability of suitable construction materials(soils) at the proposed site. The basic components of a water supply system used by the Project are shown in Figure 2.

Main concrete spillway dimensions are determined for the once in 10 years flood with a design peak precipitation of 110mm/day/with design-peak precipitation of 165mm/day while the once in 100 years flood is used for the dimensions of the auxiliary earth spillways.

Construction is undertaken by the Project with its earthmoving equipment. This follows a sequence of activities which are:

Access road preparation; setting up of camp for workers; etc.

On average, 4 months are used in building a gravity dam and 2 for a dug-out. Construction is normally undertaken in the dry months of October to May.

Implementation of project

Design of the water supply system is done solely by the Project while site selection and construction is jointly undertaken with the beneficiary community. Land and cash contribution equivalent to 10% of total cost of scheme, are made by the community prior to start of construction. Food and labour contribution is made on daily basis by the community during construction. Construction equipment and materials are provided by the Project.

A two-year guarantee period excluding construction period is given for the scheme by the Project during which all remedial works on any component of the water supply system are carried out at no cost to the beneficiary. Training of village maintenance team members is done during this period.

Water sufficiency

Yield and drawdown characteristics of some of the reservoirs indicate availability of water in sufficient qualities throughout the year. Table 2 is a presentation of the yield and drawdown characteristics of some of the reservoirs.

Constraints and problems

Notwithstanding sufficient supply of water made possible by the use of earthdams in the Project area, some pertinent problems are encountered which undermine Project efforts. High evaporation and seepage rates, unreliable intake system, excess water demand and poor water quality are the critical problems.

The evaporation and seepage criteria used seem an underestimation in the design of some reservoirs thus contributing to excessive water losses. The Kukuo reservoir, designed and constructed to similar standards as others, has since construction in 1991 been getting dried by February each year.

A floating intake system consisting of a 75 or 50mm high density polyethylene pipe(HDPE) fitted with a strainer(made of perforated HDPE) and floater is used. Plastic containers (jerry cans), widely available in the markets, were used as floaters for the intake. Cracks develop on the plastic containers with time and result in the sinking of the intake to the reservoir bottom (floor).

The actual population served by a dam is difficult to forecast due to use by neighbouring villages which are either as near as a kilometre, or 5 or more kilometres far from the dam. The need for user/beneficiary contribution to and participation in the construction of the scheme disqualifies distant villages from being part of a water supply scheme while unwillingness to join in development efforts with other villages prevent nearby villages from being part of the scheme. However, at the peak of the dry period, all neighbouring villages depend on the reservoir creating excess demand for water.

Like any surface water source, pollution of reservoirs is considerably high in the Project area. Poor sanitation and agricultural practises in the catchment contributes immensely to water pollution in the reservoirs.

Nitrates and other inorganic constituents though not monitored, are likely to exceed acceptable limits in view of the use of inorganic fertilizers by farmers in the catchments. Observed periodic algal blooms in most of the reservoirs presupposes the presence of these nutrients .

Siltation in reservoirs is not monitored. However, intense crop cultivation coupled with loose top soils in the Project area obviously contribute large quantities of sediments to the reservoirs.

Interventions

Effort is made by the Project at finding feasible solutions to the constraints mentioned above.

1. Insufficient soil investigation, based on the assumption of geologic uniformity in the Project area, is basically responsible for excessive seepage loses in some reservoirs. Village labour is used in making test pits for subsurface investigations. Pits often terminate at the hard laterite layer which in most cases is a meter below the surface. Digging tools used cannot penetrate this laterite layer and thus make it impossible to identify soil below the laterite layer. A drill has been acquired by the Project for subsurface investigations.

2. Low density plastic containers have been replaced by a high density and more UV-light resistant plastic floaters. The new floaters have been used for 11 months without being damaged compared with the average of 6 months that the low density containers were used.

3. An excess reservoir capacity is to be added to cater for future dependent villages not catered for in the design;

4. Direct contact with water in the reservoir meant for human use is avoided by the use of collecting wells and fence.

Monitoring on guinea-worm infestation in the reservoirs by the Danish Bilharziosis Laboratory in Tamale over a one year period showed no infected cyclops(intermediate host) in any of the Projects reservoirs (Kees, 1992).

However, the general incidence of guinea worm increased by 34% between 1989 and 1991 in the district where the reservoirs are situated (Bouman, 1992).

Sloping sand filter and an infiltration gallery are used in two of the dams for water treatment. The infiltration gallery reduces water turbidity from 200NTU to 5 NTU. The extent to which these filter systems improve bacteriological quality is difficult to assess due to possibility of external contamination of wells by drawing buckets etc.

Conclusion

Hydrogeological and socio-economic factors impose a limitation on the use of any alternative water supply system in the Project area of Village Water Reservoirs. The high cost of the water lsupply schemes, the complex technology used in designing and construction and associated constraints indicate a tremendous challenge to the sustainability of the water supply schemes at Project and village levels. Similar challenges can be expected elsewhere where physical and social factors dictate the choice of surface water as the only feasible alternative. Research is therefore needed on low-cost surface water supply systems for areas of similar physical and social characteristics if the objective of the International water supply and sanitation decade are to be met in such areas.

References

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Table 1. Examples of constructions undertaken since 1988

Community	Type of construction	Year of construction	Design population		Capacity at full supply level (m^3)	Cost in cedis	Cost per capita(Human) (in cedis)
			Human	Live-stock			
Chirifoyili	Gravity dam	1988-89	6930	4500	135,650	35,181,261	5,077.00
Buyili	Dug-out	1989-90	360	400	13,500	11,327,665	31,466.00
Aseiyili	Dug-out	1989-90	300	365	10,000	6,200,334	20,662.00
Yong-Dakp.	Gravity dam	1989-90	2150	1800	81,000	16,552,840	7,700.00

EXCHANGE RATE: ¢350 - US$1 (1989); ¢340 - US$1 (1990)

Table 2. Yield and drawdown characteristics of some reservoirs

Reservoir	Type of construction	Capacity (m^3)	Reservoir Yield and Drawdown							
			Designed				Observed			
							1990		1991	
			Full supply level (m)	Volume (m^3)	Lowest supply level (3)	Volume (m^3)	Highest Level (m)	Lowest Level (m)	Highest Level (m)	Lowest Level (m)
CHIRIFOYILI	Gravity Dam	135,650	9.77	135,650	6.21	5,025	9.71	6.18	9.76	6.16
BUYILI	Dug-Out	13,500	9.80	13,500	6.55	2,300	9.78	6.50	9.79	6.50
ASEIYILI	Dug-Out	10,200	8.60	10,000	6.63	3,200	8.55	6.60	8.56	6.59
YONG	Gravity-Dam	81,000	9.50	81,000	6.67	2,500	8.41	6.65	9.39	6.52

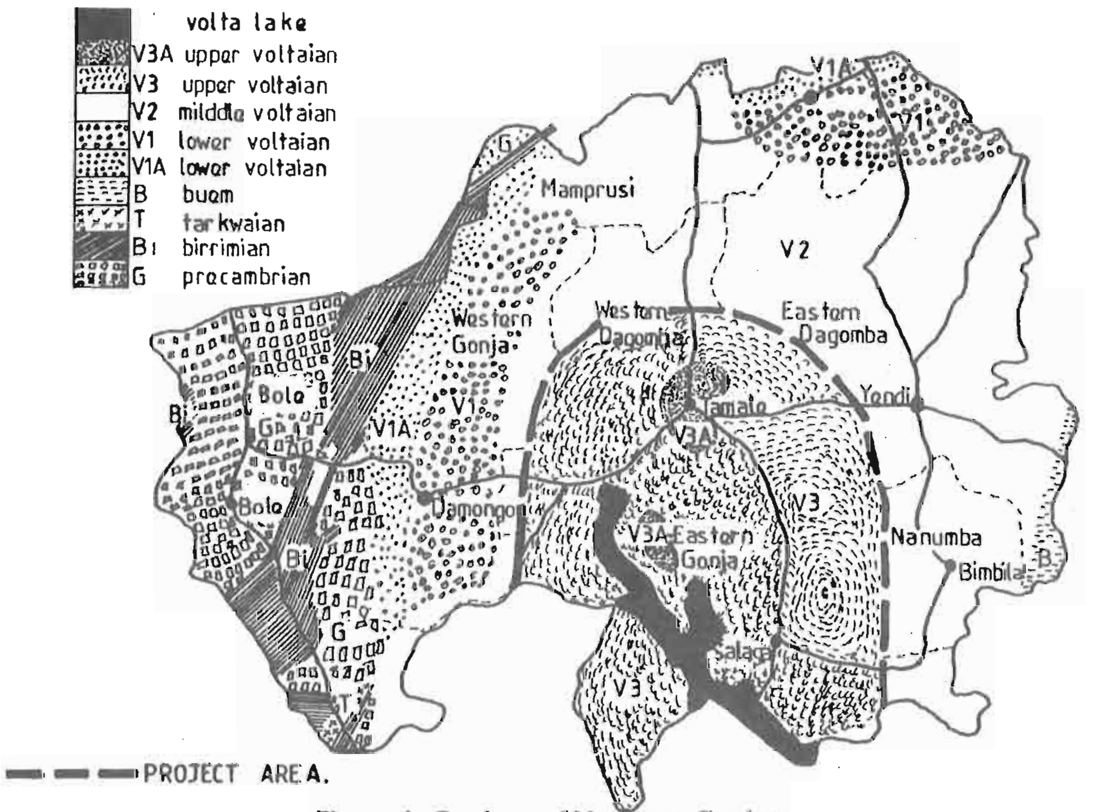

Figure 1. Geology of Northern Region
(Source: Tod, 1981)

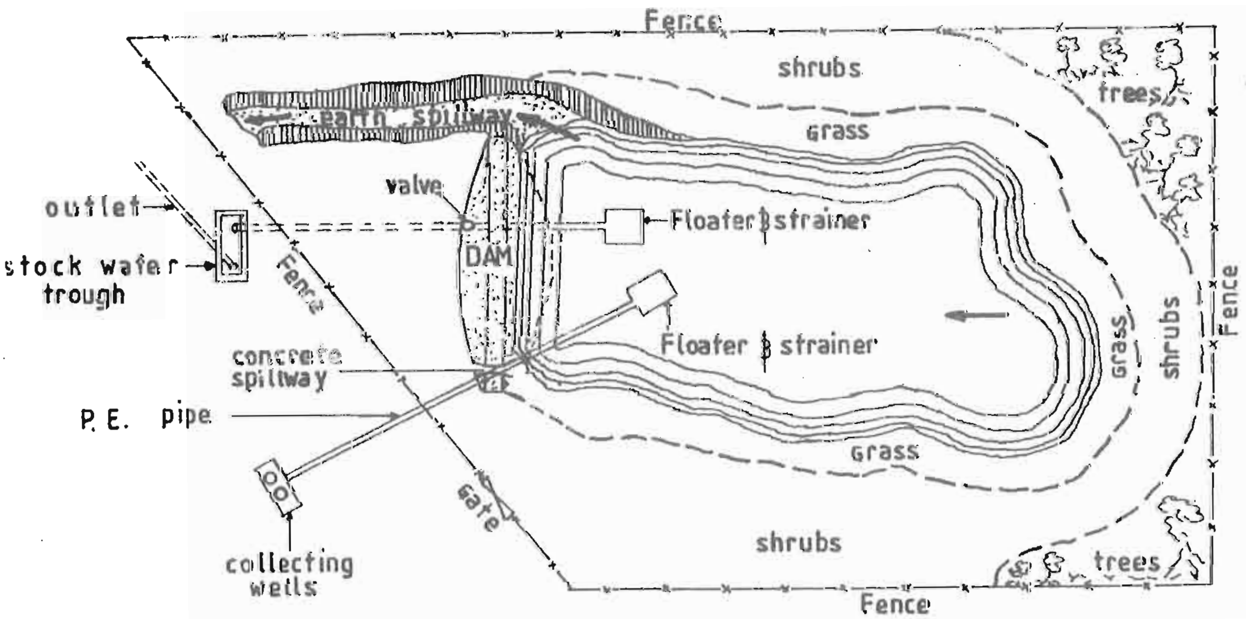

Figure 2. A typical layout of a water supply system