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Handpumps or reticulation systems?

INTRODUCTION

Engineers are given the responsibility of providing the best quality service at the lowest cost. In many cases the least cost consideration has been taken as referring to the capital cost only. However, increasingly engineers are having to recognise that they must design for the lowest possible lifetime cost - that is the smallest overall cost for the lifetime of the installation including operation and maintenance costs as well as capital cost.

This is particularly important when considering the provision of clean water to the rural areas of the less developed countries. With an estimated eighty per cent of the people still living in the rural areas and with sixty per cent of these still without an improved supply there is a large amount of work outstanding. In order to make any impact on this situation, costs have to be kept to a minimum. With an estimated forty per cent of existing improved supplies out of action at any one time, operation and maintenance costs also have to be designed for the lowest possible cost to ensure a better chance of the funds being available.

Appropriate technology means the best and most economic technology for people in a particular situation. This requires an open approach to problem solving which may lead to unconventional solutions. This paper describes a Least Cost Analysis of the lifetime costs of two methods of providing clean water supply to the Terai Region of Nepal.

As part of a seminar for senior engineers from the Water Supply and Sewerage Corporation and the Department of Water Supply and Sewerage the participants were asked to investigate the lifetime costs of using a conventional pumped borehole with overhead storage tank and reticulation system compared with using tubewells and handpumps.

THE TERAI REGION AND SOURCES OF WATER

The Terai Region of Nepal is the five-hundred mile long strip of lowland bordering India. It is an area of marshy plain and thick jungle as well as an area of high agricultural productivity with a rapidly growing population. It is founded on the Indo Gangetic alluvium, an area with beds of coarse sands, gravels and boulders of varying thicknesses with shallow and deep aquifers, partly interconnected and confined, with an estimated tubewell yield of 50-100 m^3/hr (Raghunath 1982)

Hand dug wells and simple tubewells to an average depth of 30 m provide a most useful water source. The tubewells are sunk by the sludger method at an average rate of two wells per day with six men.

The larger centralised systems typically consist of one or two 200 mm boreholes approx 120 metres deep with induction motors and pumps feeding into an overhead tank and from there by gravity into a town-wide distribution network. In addition a standby generator will often be required in case of power failure.

DESIGN CRITERIA

This study follows the local standard design criteria of providing 100 litres of clean water per person per day. In the rural towns the design assumes that one quarter of the population will be served by individual household connections for an average of ten persons each. The remainder collect water from communal standposts installed at the rate of one per two hundred persons.

The population of the Terai is growing very quickly with considerable inward migration from the hills as well as from over the border. Standard design procedure is therefore to consider a growth rate of 4% per annum.

HANDPUMPS AND TUBEWELLS

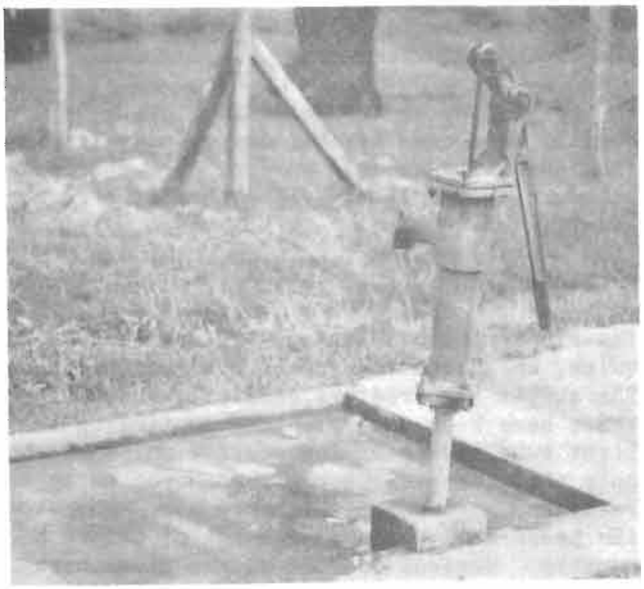
The sludger method of sinking tubewells is quick, cheap and requires little equipment. The skills required are easily learnt although there have been some problems in finding the right sand layers of the aquifer which may be only three metres thick. Though the water is free from carbonates which can block the slots the brass well screens have not proved to be durable. Various plastic alternatives have been tried and also different slot sizes experimented with in order to minimise sand collection.

The three metre section of 37 mm GI rising main supports the pump (which is mounted directly onto it) and also prevents mice from attacking the HDPE riser. The most commonly used pump is the Bangladesh New No 6 Pump which is a shallow well suction pump made primarily in Bangladesh but recently being brought into production in the Terai and Kathmandu under the sponsorship of UNICEF. It is constructed almost entirely from cast iron with the plunger having a moulded PVC cup washer and the check valve comprising a simple leather flap weighted with cast iron. The pump discharges onto a 1.8m square concrete drainage apron. There have been difficulties experienced with the large quantities of waste water which result from the pump area being used as a bathing site for upwards of 200 people and care is required by communities or households to prevent this ponding and becoming a health hazard.

The experience of UNICEF suggests a capital cost for each tubewell complete with hand pump of 3230 Rs (1984 prices, $1 = 17 Rs).

Where the pumps have been maintained on a voluntary basis very low costs have resulted. Where provision has not been made for maintenance , between 10% and 15% of the pumps have been inoperative after two years. Where an agency is responsible for maintenance, estimated costs range from 45 Rs per pump per annum for a group of over 2000 pumps up to 200 Rs per annum for 100 pumps.

For the purpose of this analysis the handpumps have been assumed to have a life of fifteen years with regular maintenance and an overhaul at seven years including a new screen, a renewed hole and major spares.



Bangladesh No 6 Handpump

BOREHOLE, TANK & RETICULATION

The conventional centralised system already described is well understood by design engineers. For the purpose of this analysis 'as built' capital costs have been taken from a system designed for a future population of 12,000, costing 3.7 million Rupees in 1983.

Pump house and overhead storage tank

Capital costs for larger and smaller schemes have been calculated by using a scale factor of 'a' = 0.5 where Capital Cost equals a Constant times the Capacity raised to the power 'a'. Recommended values of the scale factor are a = 0.4 for elevated storage and a = 0.5 for distribution networks (EDI Ringskog 1983).

Other information suggests that future capital costs could be expected to be considerably higher than these figures. However this study assumes that recent costs for both hand pumps and reticulation systems are an accurate enough guide for the purposes described below.

The analysis has been carried out for a period of fifteen years being the design life of a pumped system recognised by various agencies. It is also the Optimal Design Period for a pumped elevated storage and distribution system using a Scale Factor of 0.5 and a Discount Rate of 10% in order to avoid the wastage of over designing a scheme that cannot be used to capacity for many years to come (EDI 1983).

The cost of installing a household connection is 425 Rs and of making a connection and building a communal standpost is 825 Rs. It is assumed that the main distribution network is installed at the same time as the pumping and storage system but connections are made to suit the demand of the growth in population. Similarly it is assumed that handpumps are installed to meet the population increase as it occurs.

The construction period for the smallest pumped scheme has been taken as two years and for the larger systems as three years with construction costs distributed equally over the period.

Operation and Maintenance costs for the pumped scheme have been taken as 3% of total cumulative capital costs per annum.

LEAST COST ANALYSIS

An estimate is required of the Discount Rate which should be the marginal social rate of return on investment. This can be difficult to ascertain and current experience suggests that a discount rate of between 8% and 10% is a useful operational guide (ODM 1977). This study has taken a figure of 10% whilst recognising that high discount rates tend to favour projects with relatively low capital costs and relatively high operation and maintenance costs (Baldwin 1983).

The analysis was designed to investigate the relative merits of using the two different technologies at comparable standards of service. This was considered over a range of town sizes, from initial populations of 850 with a design size of 1500 up to a town of 30,000 growing to 50,000 in fifteen years.

The Net Present Values of total costs over the fifteen year design period are tabulated below and illustrated in Figure 1. It had been anticipated that whilst the handpump option might be most economical for the villages the centralised system would quickly become more economical for the towns. This does not appear to be the case as the NPV curves for each alternative never cross - the handpump option is always more economical. Another situation was then considered whereby each household would have its own supply point, whether by handpump or from connection to the mains. This being taken as the ultimate standard of supply.

Table 1

Design Population	NET PRESENT VALUES: One Water Point per 200 for 75% & one per 10 for 25%		One Water Point per Household of 10	
	Reticulation System	Handpumps	Reticulation System	Handpumps
1,500	1,425,200	117,350	1,458,560	385,500
6,000	2,653,900	486,120	2,763,575	1,542,000
12,000	3,751,600	967,670	3,983,100	3,084,000
25,000	5,342,700	2,023,715	5,815,500	6,425,000
50,000	7,953,000	3,883,140	8,575,200	12,850,000

The results of this analysis as illustrated in Figure 1 highlight some interesting points:

For all sizes of design population the standard service with hand pumps can be provided for approximately half the cost of the standard service with reticulation system.

For populations under 17,500 the ultimate service with handpumps can be provided more cheaply than the standard service with reticulation.

For populations under 20,000 the ultimate service with handpumps can be provided more cheaply than the ultimate service with reticulation.

The ultimate service with reticulation can be provided for only 10% more than the standard service with reticulation.

There are also other factors which are less easy to quantify. It is worth noting that whereas a handpump used for only one household should have a long and trouble-free life, a centralised system commonly operates for only a few hours each day. Indeed, in the system investigated water was only available for two hours in the morning and three hours each evening.

Because of the problem of finding recurrent costs, fuel and spare parts are often in short supply. This can lead to loss of pressure in the distribution network and subsequent ingress of polluted water.

Notwithstanding these economic and technical advantages of using handpumps and tubewells, there is a major problem in ensuring their widespread acceptance as appropriate technology. To an engineer responsible for water supply there is only a limited interest or technical challenge involved. Designing an elevated water tank out of reinforced concrete and arranging contracts and supervising construction is a task well suited to an engineers training, whereas installing several thousand simple handpumps may not always be seen in the same light.

However, ultimately an engineer's skills will be judged by the quality, quantity and economy of the services supplied and if clean drinking water is the goal then in the circumstances described above, handpumps and tubewells look to be the most suitable solution.

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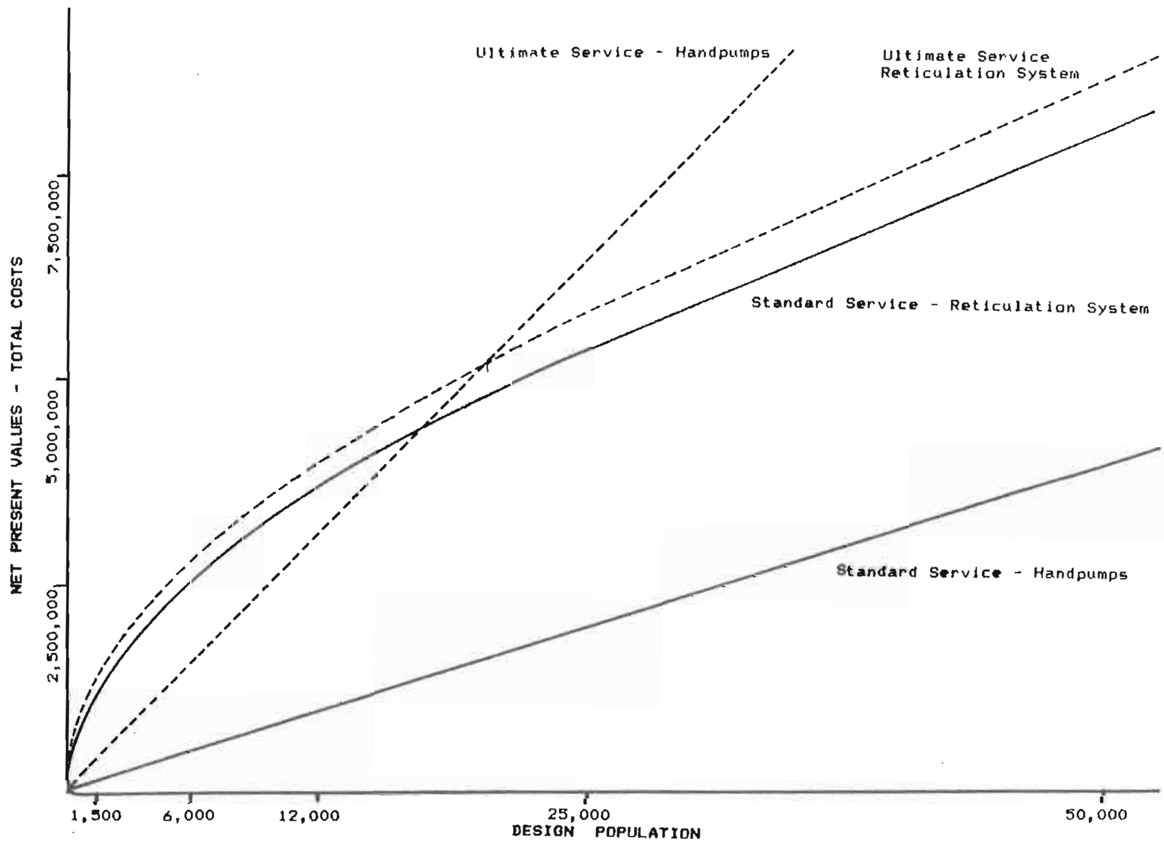

Figure 1

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