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PEOPLE AND SYSTEMS FOR WATER, SANITATION AND HEALTH

Piloting trickle-feed distribution in rural South Africa

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IN RECENT YEARS in South Africa, there has been growing concern over the sustainability of conventional standtap schemes installed, since 1994, in an attempt to redress developmental imbalances of the past. A report by the Mvula Trust, a South African water supply and sanitation NGO, suggests that the impetus to deliver has been at the expense of long-term project sustainability. Of the water projects evaluated, the report identifies cost recovery as a persistent problem, through unwillingness or inability of consumers to pay, and costly designs. (Breslin, 1999).

In an attempt to improve cost recovery, a number of standtap reticulation schemes have installed mechanical or electronic prepayment supply units. These allow consumers to buy coupons, or credits on a 'smart' card, which are exchanged for water at a vending tap. These initiatives have had limited success, due to high installation costs, reliance on advanced technology and low water usage by the consumer. In one electronic prepayment scheme, average consumption was only 1.2 litres/person/day, clearly well below the minimum standard and insufficient to recover high capital costs (DWAF, 2000).

It is argued that the government's basic level of service - 25 litres/person/day at a distance of 200m (DWAF, 1994) does not meet the demands at community level. Often people do not pay for a communal supply when there is an alternative, 'free' water source, e.g. river, available. With the South African government implementing a free basic water supply of 6,000 litres per household per month, expectations for water service provision are high.

People generally express a desire for yard connections, and state that they are willing to pay an initial contribution and an appropriate tariff for this higher level of service. In rural areas, the reality remains that communities are not able to afford current yard connection options and have limited capacity to manage complex, metered distribution systems.

In view of this, alternatives are needed. One such initiative, 'trickle-feed' distribution, has been piloted.

Trickle-feed design concept

A trickle-feed water distribution system is essentially a reticulated piped network that delivers water to a tank situated at each household. Located inside each tank is a 'trickle-feed box', consisting of a small plastic container with ball float valve inside, as shown in Figure 1. An orifice is drilled into the side of this box, sized to provide a set flowrate into the tank. Water enters the top of the tank directly into the trickle-feed box which fills to the level determined by the ball float valve. This then sets a fixed head of water ('H' on Figure 1) above the orifice, which causes a constant flow to 'trickle' into the tank.

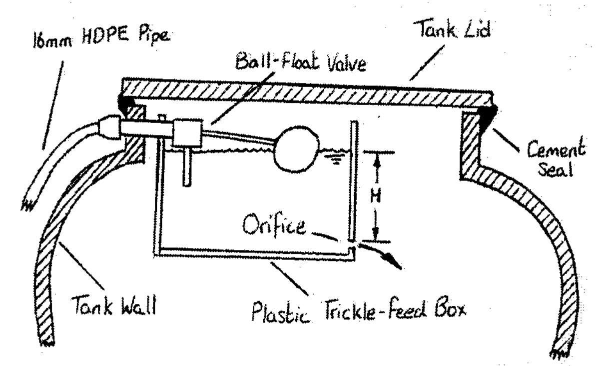

Figure 1. Concrete trickle-feed tank section

Water is drawn-off from the tank, through a tap at the base, as and when required during the day. The draw-off out of the main tank does not affect the flow rate coming into the tank via the trickle-feed box. The tank fills steadily throughout the day and night, regardless of how and when water is taken from the tank. Any peak flow factors in the system are eliminated, so supply pipes do not have to be larger in size to account for this, as happens with conventional standtap designs.

It is possible to have differing levels of service by having more than one orifice. For example a box could be made with up to three orifices, allowing a household to receive a daily volume of either 200, 400 or 600 litres, depending on their level of demand and willingness-to-pay.

A trickle-feed system requires a tank to be installed at each household. There are no restrictions as to the type of tank used, providing each has a trickle-feed box installed at the top. This offers another area where the household can choose their level of service, as different types of tank - from outside ground standing to indoor roof – can be installed.

Reticulation pipelines for a trickle-feed system should be designed to ensure that appropriate long-term demands of the community can be achieved. An example in a rural area would typically be that each household can be fitted with a roof tank with a supply of 600 l/day.

Benefits of a trickle-feed system

Benefits of implementing a trickle-feed system include:

- Water is brought within the household, removing the need for carrying water over a distance. This decreases the burden of labour on women and children, freeing up

time for more productive activities, including the productive use of the water itself;
- With the water more accessible, households are more likely to use their full set daily quota of water, enabling positive health impacts (assuming sanitation and hygiene practices are also improved);
- Communities are generally more willing-to-pay for affordable, reliable higher levels of service, increasing cost recovery;
- The set household consumption level allows a flat-rate tariff structure. Those who default on payments can be disconnected from the main supply without affecting the supply to other users;
- Compared with household metering and pre-payment schemes, a trickle-feed system uses simple low-cost technology (e.g. HDPE pipes, float valves) that can easily be maintained and replaced if necessary;
- An equivalent of around one day's storage is assured at each household, providing additional security and continuity of supply. On-site storage allows the size of expensive bulk reservoirs to be reduced;
- Pipelines through the community are smaller in diameter, as the trickle-feed supply has much lower flows through the system. Capital costs of pipelines are significantly reduced;
- Water pressures and flowrates in the pipelines are low, so less leakage and wastage occurs;
- Water losses at the draw off point, i.e. faulty tap or leaking tank, are limited in the system to the set flow through the trickle-feed orifice. On standtap or metered systems, losses at a draw-off point can be extremely high; and
- Household connections with trickle-feed tanks can be retrofitted to existing standtap reticulation systems. The low flowrates and pressures required enable a conventional standtap system to be upgraded with household tank connections without relaying the bulk reticulation mains.

Constraints of a trickle feed system

The major constraint of a trickle-feed system is that each household is limited to the maximum daily amount set by the control orifice(s). Consequently there is no allowance for extra water needed for exceptional events, such as weddings and funerals. Households will generally 'purchase' water from neighbours in such instances. Similarly, the system sets a minimum supply to each household each day. This may result in people paying for a supply of 'potential' water that they do not use. Careful tariff setting, plus allowances for cross-subsidisation and exemption from charges for vulnerable groups (eg. widows, the disabled) should be considered.

On a trickle-feed system, it is also necessary to ensure that households do not vandalise or tamper with the trickle-feed box, as this affects flows and pressures in the rest of the system. A way to achieve security is to lock or seal the household tanks by a means that can only be opened by authorised maintenance staff.

Pilot project background

A pilot trickle-feed project, located in Nondayana, kwaZulu-Natal, is currently being implemented. The project area encompasses some 180 households (approximately 1,800 people) dispersed over an area of 8 km^2. Most households have an income between R500 (US$62) and R800 (US$100) per month through state welfare.

The developmental infrastructure in the area is minimal. There are no electricity or telephone connections and the only sanitation initiatives are a few, simple pit latrines. The only safe water supplies are three handpumps, which are often in-operational. Those living far from a handpump rely on rivers, streams or small springs, while many families who can afford tin-roofs have some form of rainwater catchment. The community suffers from diseases endemic in most rural areas of Southern Africa including diarrhoea, AIDS and TB. The recent outbreak of cholera in the region, which killed eight people in the Nondayana community, highlights the desperate need for improved water, sanitation and hygiene practices.

In 1996, a water committee was elected in the community under the umbrella of the Development Committee. Following discussions with the community regarding feasible water supply options, an application was submitted for government funding to support a conventional standtap reticulation system. At the feasibility stage, a crude willingness-to-pay survey indicated the demand for a high level of service. However, it was deemed that the connection charge, in addition to high monthly charges of a metered system, would be unaffordable by most. When the trickle-feed concept was discovered, the issues of implementing a pilot project were discussed at a community meeting. The majority of the community supported the proposal for a high level of service at relatively low initial and monthly charges.

There remained a minority, mainly men, who perceived these costs to be too high. To improve community awareness of the scheme, an information pamphlet was produced. Sketches of various tank types were included (see Figure 2), along with the benefits, constraints and cost implications of each option. The pamphlet also briefly explained the trickle-feed system, the water committee's role, reasons for a monthly tariff, limitations of the controlled supply system and household maintenance requirements.

System design and implementation

The main water source for the scheme is a river, supplemented by a gravity-fed spring to improve sustainability. Raw water is pumped from the river to an intake roughing filter. From this filter, a high-lift pump delivers to a series of roughing and slow-sand filters, and storage reservoir with simple chlorination. The treated water then flows by gravity via small diameter HDPE pipes (i.e. 16mm to 50mm) to a tank at each household. The trickle-feed box in each tank has one orifice, allowing a maximum flow into the tank of 400 litres/day.

It was deemed appropriate to supply all households with the same, higher rate of water as; a supply of 400 l/day (40

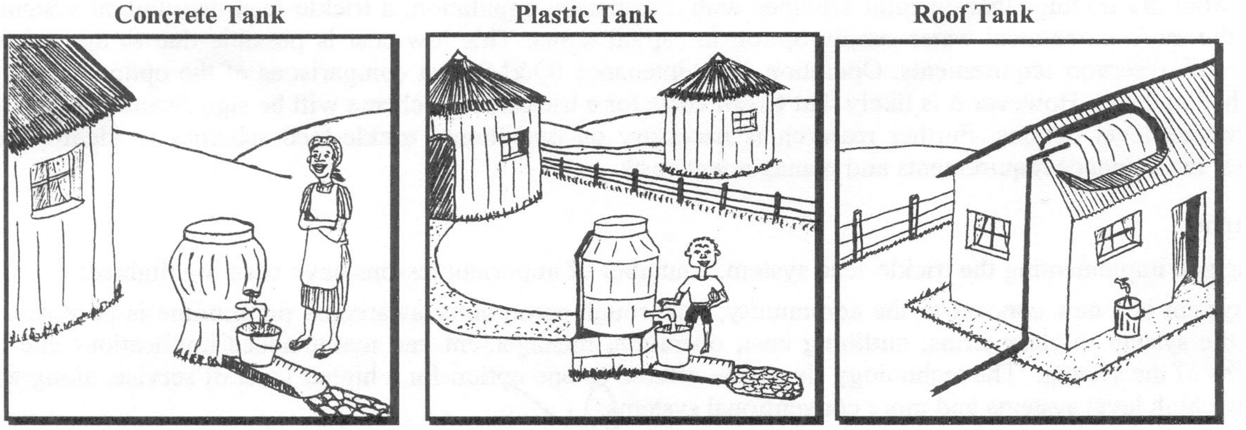

Figure 2. Tank type sketches taken from community information pamphlet

l/person for an average household) allows sufficient water for hygiene purposes, and the monthly tariff is simpler to manage with the same household supplies throughout. As the community becomes familiar with management of the system, individual household supply rates and tariffs can be modified.

Choice exists in the level of service available, as households can chose from three tank design options (see Figure 2). The lowest cost is a 180 litre concrete tank, constructed on-site by plastering onto a hessian frame (similar to unreinforced mortar water jars common in many developing countries). The second option is a 200 litre plastic tank supported on a plastered hessian, or similar, base. The third option is a 180 litre plastic roof tank that provides sufficient pressure for household plumbing.

In order to create a sense of ownership, each household has been asked to contribute towards the cost of their tank. The contributions and capital cost of tanks are shown in Table 1.

The construction phase commenced in October 2000 and, at the time of writing, was nearing completion. Although the pumps were not commissioned, the spring source enabled the first of the trickle-feed tanks to be connected and monitoring of the system to commence.

Table 1. Household Tank Costs

Tank Type	Cost	Contribution
Concrete	R200 *(US$25)*	R50 *(US$6)*
Plastic	R350 *(US$44)*	R150 *(US$18)*
Roof	R320 *(US$40)*	R150 *(US$18)*

Cost comparisons

The capital costs of rural reticulation systems implemented in South Africa vary widely, depending on the level of service and cost recovery infrastructure installed. A study has been undertaken, using Nondayana as a typical rural project, to determine how cost effective a trickle-feed system is when compared to other systems available. For this investigation, it was assumed that each of the systems had identical pumping and treatment systems. The different systems considered had the following boundary conditions: a standtap scheme has 18 taps that allow a supply of 15 l/min; a trickle-feed system allows a daily flow of 600 litres to 180 household tanks; a yard connection scheme has 180 yard taps that supply 10 l/min. A summary of the findings of this study is detailed in Table 2 below.

It is evident from the findings that on rural schemes with a dispersed population, a trickle-feed distribution system is likely to be the most economical water supply option in capital terms. This low cost is possible due to the reduced pipeline and bulk reservoir requirements. Operation & maintenance (O&M) cost comparisons of the options have not been researched in detail. However it is likely that O&M costs for a trickle-feed scheme will be significantly lower than other high service level options. Further research is necessary on operational trickle-feed schemes to identify cost recovery rates, maintenance requirements and management costs.

Lessons learnt

In developing and implementing the trickle-feed system, a number of important lessons have been highlighted:

- As the system is a new concept to the community, a thorough community awareness programme is necessary to explain the system in clear terms, outlining cost, operation, management and maintenance implications and the limitations of the system. The technology should be offered as one option for a higher level of service, along with alternative high level systems and more conventional systems;
- Design modifications, to suit needs and community demand, have been necessary. Open discussions with

Table 2. Cost comparison of reticulation designs for a typical rural project

System Type	Cost, rands				
	Pipeline, Fittings & Trenching	Bulk Reservoirs	Supply Points	Prepayment Extras	Total
Conventional Standtap	179 500	65 000	10 800	0	255 300
Mechanical Prepayment Standtap	179 500	65 000	77 040	14 400	335 940
Electronic Prepayment Standtap	179 500	65 000	27 900	40 000	312 400
Trickle-feed Distribution (Concrete Tank)	151 700	38 000	36 000	0	225 700
Trickle-feed Distribution (Plastic Tank)	151 700	38 000	63 000	0	252 700
Conventional Metered Yard Connections	558 500	65 000	64 800	0	688 300
Electronic Prepayment Yard Connections	558 500	65 000	132 300	40 000	795 800

Cost estimates at Apr 2001 prices; Systems designed for minimum pipeline diameters within standard boundary conditions; Bulk reservoir costs based on 48 hr storage requirement (24hr for trickle-feed with on-site storage); Supply point incorporates standtaps, household tanks and household metering; Prepayment extras include hardware, software and specialist training.

the committee and community have enabled solutions to system limitations to be sought. For example, the plastic float valves of the trickle-feed units have a limited pressure rating (40m head), so a brass float valve suited for higher pressures (160m) is being developed. This offers a more robust, maintainable option at similar cost. The community requested lockable taps, fearing people would steal water while they were away.

- Initially, households were slow to pay connection charges, being wary of contributing to a system that was not operational, or fully understood. Payments increased with raised community awareness and almost 100% payment has been achieved in areas where tanks are constructed, as families are willing to pay for a tangible system brought within their own property; and
- This scheme will have a major impact on the daily lives of the community, in particular the women and children. Children collect water each day after school and women spend up to two hours walking to the river to wash clothes. A household supply will free up time and energy for other activities. Informal discussions have shown that the women are very happy with the household tank system and understand the management, maintenance and tariff requirements. Given that the women of the community acknowledge the benefits of the scheme, it is perceived that cost recovery rates will be high.

The Nondayana trickle-feed system is still not fully operational and further technical and social problems may come to light in the following months. The Water Research Commission (WRC) is funding a project to monitor and evaluate the scheme and findings should be available in early 2002. Monitoring household water usage will help determine whether additional health promotion is necessary.

Conclusion

To improve sustainability of rural water supply schemes in South Africa, there is a need to develop innovative and appropriate technologies that enable costs to be recovered, whilst meeting peoples' expressed demand for higher levels of service. This paper has introduced the 'trickle-feed' concept as an alternative to the current design strategies that have generally proved to be unsustainable and ineffective at impacting health. The Nondayana pilot project has shown that a trickle-feed water supply system is a cost effective, viable option for meeting rural communities' demand for higher levels of service. With scope for further development of the concept and longer term monitoring and evaluation, it is clear that the trickle-feed principle has great potential to be implemented on a larger scale in rural locations.

References

BRESLIN, E.D. (1999) *Lessons from the field; rethinking community management for sustainability.* Paper presented at the Rural and Peri-Urban Water Supply and Sanitation in South Africa – Appropriate Practices Conference, East London, South Africa.

DWAF (1994) *Water Supply and Sanitation Policy White Paper.* Department of Water Affairs and Forestry, Pretoria.

DWAF (2000) *Site Evaluation of Electronic Prepayment Water Metering Cost Recovery Systems: Final report: September 2000.*

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