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WATER AND SANITATION FOR ALL: PARTNERSHIPS AND INNOVATIONS

Cost effective designs for rural water schemes

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WATER SUPPLY SCHEMES for rural and urban fringe (peri-urban) communities generally cost more per capita than for urban communities in formal township layouts. The main reason for the increased cost is the lower population density in rural and urban fringe communities. Cost per capita is often the key criteria used to determine the feasibility of schemes.

Consequently engineers are continuously under pressure to reduce the capital costs of water supply schemes to these communities by using more appropriate design standards.

There are many established design standards that can be adjusted to suit the specific requirements of rural and urban fringe water supply schemes to effect a reduction in the capital costs of these schemes. Most will reduce the capacity of the scheme and can result in operation and maintenance problems. These problems nearly always result in increased operation and maintenance costs.

This paper discusses the methods of reducing the capital costs in the design of rural water supply schemes, the implications of adjusting these design parameters and identifies design parameters that have a net positive effect on a scheme.

It should be noted that community participation in agreeing to the standards discussed in this paper is essential to the success of the project. The communities must be informed why certain standards are adopted and how these will impact on them.

Components of a water supply scheme

A typical water supply scheme comprises of the following components:

Bulk supply component

- Water source
- Water treatment works
- Pumpstations
- Bulk pipelines
- Valve and meter chambers
- Emergency storage and balancing reservoirs

Reticulation component

- Reticulation distribution pipelines
- Valve and meter chambers
- Break pressure devices
- Standpipes and individual connections
- Water offices

Methods of reducing capital costs

Reducing the capital cost of rural and urban fringe water supply schemes is generally carried out by the following methods:

- Reducing the capacity of components of the scheme (i.e. water treatment works, pipelines, pumpstations and reservoirs).
- Reducing the numbers and size of system components (i.e. valve and meter chambers and assemblies).
- Appropriate construction specifications for underground pipelines.
- Reducing the length of reticulation distribution pipelines.
- Reducing the minimum diameter of reticulation distribution pipelines.

Reducing the capacity of components

The following design parameters are normally adjusted to reduce the capacity of components of a rural water supply scheme:

- Realistic and not optimistic initial and future consumption requirements.
- Realistic population growth estimates.
- Design life of a component.
- Peak design factors.
- Minimum diameter of reticulation pipelines.
- Fireflows for pipelines.
- Emergency and balancing storage of reservoirs.

Determining realistic initial and future consumption requirements and population growth estimates will result in significant capital cost savings without increasing operation and maintenance costs. Future consumption will increase in rural communities due to population growth and increased demand per capita from a change in water usage practices. Modelling the timing of the increasing demand will greatly assist in optimising the sizing of system components

In KwaZulu-Natal, South Africa the initial demand for rural water schemes is 5 to 10 l/capita/day with an estimated short term high of 25 l/capita/day. The long term high could increase to 50 to 60 l/capita/day depending on the affluence of the community and whether the initial water conserving habits of the community changes to a higher water consuming lifestyle.

Treatment works, pumpstations and reservoirs

It is generally accepted that capital costs of water supply schemes can be delayed by designing the water treatment works, pumpstations and reservoirs in modular units with the initial unit having a short design life of say 5 to 10 years. With these components there will be little overall increase in the total project cost by adding units when required and not upfront.

Reducing the emergency and balancing storage of reservoirs from a norm of 48 hours to 24 hours of average daily demand will reduce costs but will significantly increase operating problems. This will especially be the case in rural areas where long distances to specialist maintenance firms (i.e. pump and motor engineering firms) will result in support not being immediately available. In fact it is recommended to increase the storage of reservoirs to 60 hours where maintenance specialist support will not be immediately available.

The capacity of the water treatment works and pumpstations can be reduced by using a realistic daily demand peak factor. The average daily demand peak factor takes into account the seasonal variations of the annual average daily demand and ultimately 24-hour day operation at peak periods. Experience has shown that in the major townships of KwaZulu-Natal, South Africa a peak factor of 1.3 for 24 hour pumping day is more realistic than the standard factor of 1.5 for a 20-22 hour pumping day normally given as a guideline. This reduced system capacity will not create operating problems especially if there is sufficient reservoir storage.

Bulk pipelines

The major capital cost of most rural water supply schemes is the supply and installation of the bulk and reticulation pipelines.

The design life for sizing pipelines is generally 20 years. The supply and delivery cost of piping is half that of the total supply and installation cost of large diameter (greater than 300 mm) bulk supply pipelines. It is therefore cost effective to reduce the capacity of the bulk pipelines to cater for realistic and not optimistic future water demands.

The bulk supply pipelines could be sized using a 20 year design life with a peak factor of 1.3 and the projected average demand in year 20. This could vary between 10 to 50 l/capita/day depending on the projected affluence and lifestyle change of the community.

Reticulation pipelines

It is not considered cost effective to reduce the design life of reticulation pipelines as the supply and delivery cost of piping is 17 per cent of the total supply and installation cost. From experience we have found that 70 per cent of reticulation pipelines are 63mm in diameter or less. Any reduction in the design life of these pipelines will not reduce the diameters significantly especially if the minimum pipeline diameter is 50mm.

For the same reason it is recommended that the minimum pipeline diameter of say 50mm should not be reduced. Reducing minimum pipeline diameter from say 50mm to 40mm will result in at most a 2 to 3 per cent cost saving with a corresponding 60 per cent reduction in capacity.

Pipelines are not designed for fireflows in rural water supply schemes. This is in line with the philosophy to select appropriate fire fighting equipment to suit the circumstances of the area, rather than adding significant cost to the reticulation with fireflows dictating pipe sizes.

Reducing the numbers and size of valve and meter chambers

Reducing the size and numbers of valve and meter chambers will not significantly reduce the project capital cost but will greatly increase the operating and maintenance problems. It should be noted that easy access by operating or maintenance staff to valve and meters is essential for the successful operation of a water supply scheme.

Reducing or doing away with bulk meters on reticulation pipelines does not allow for water balancing which is essential for water loss management. Reducing air ,scour and isolating valves increases maintenance time for repairs resulting in increased operating costs. Reducing the size of valve and meter chambers can result in increased time to read meters and carry out valve and meter maintenance.

Appropriate construction specifications for underground pipelines

The following underground pipeline installation design standards will reduce capital costs without causing operation and maintenance problems:

- Pipeline depth of cover (minimum 600mm).
- Trench width (minimum 300mm).
- Appropriate bedding and backfill specification to minimise imported bedding.

Reducing the length of reticulation pipelines

Reducing the length of reticulation pipelines will result in major capital cost savings to the service provider for rural and urban fringe water supply schemes without significantly impacting on the operation and maintenance of schemes. It does however impact on the connection costs to the consumer. This must be agreed with the effected communities up front.

In South Africa a design requirement is to provide water within an average distance of 200m of all dwellings for rural water supply schemes. If the service provider routes pipelines parallel to existing roads and tracks to within 200m of each dwelling and not to each dwelling which on average could be 50m from the distribution pipelines there could be a reduction of required pipelines to the service provider of as much as 50 per cent. The consumer will be responsible for the pipeline and related fittings from the service provider connection at the distribution pipeline to where the consumer requires the water supply (i.e. yard tap or plumbed to dwelling).

A design philosophy for more densely populated rural and urban fringe communities is to route pipelines to within 200m of all consumers but where there are two or more dwellings at the end of a road or track, the pipeline will be extended up to the dwellings and not 200 m away. The motivation behind this philosophy is to reduce the instances of numerous small diameter pipelines (spaghetti lines) being installed over other consumers' properties. Experience has shown that by strictly adhering to the policy of routing pipelines to within 200m of any dwelling and ignoring the philosophy described in the previous paragraph, it is possible to effect a 40 per cent reduction in the length of pipelines. This will result in a 40 per cent reduction in the cost of the reticulation component of the project. Although this added reduction in pipeline length will create operational and maintenance problems, they can be justified where funding is limited.

Again the community should be informed of the options available and the implications of each option to the consumer regarding level of service versus the size of the reticulated area with a fixed budget.

Conclusions

The following methods of reducing rural water supply scheme capital costs will not create significant operational and maintenance problems and will therefore have a net positive effect on a scheme:

- Determine realistic initial and future consumption requirements.
- Determine realistic population growth estimates.
- The design of treatment works, pumpstations and reservoirs should be in modular units with the first unit having a design life of 5 years. The peak factor of these components should be reduced to 1.3.
- Fireflows will not be used when sizing pipelines.
- Use appropriate construction specifications for underground pipelines.
- Reduce the length of reticulation pipelines where possible.

The most significant method of reducing rural water supply scheme capital costs described above is reducing the length of reticulation pipelines. Although this method will reduce the costs of the scheme to the service provider (this could be the community water authority) it will increase connection costs to the individual consumers. The level of service will depend on what the consumer can afford to pay.

With a limited budget this method will provide water to the most consumers.

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