RWSSP: Technical Advisory Note 4.9
Water Supply - Gravity Fed Systems

Introduction

A gravity fed system (GFS) is usually the best water supply option because it generally meets water use needs at the user's doorstep, is relatively simple to maintain, and can be developed by the community to household level supply. Because every village is different in relation to its water source, no two GFS designs will ever be the same. An experienced water engineer can maximise the flow of water into a community from the source, yet minimises future maintenance requirements. Community management of the GFS is most effective if it begins during the design stage.

The following is a brief summary of GFS design glossary of terms and values, parameters and procedures which should be fully understood before designing a GFS. It should be accompanied by the RWSSP GFS manual. This is followed by some basic design parameters and the design procedure. Although relatively simple in concept, there are repeated mistakes made in their design and construction. Some common mistakes are listed which if avoided, will maximise flow from the source and minimise maintenance. The conclusion refers mainly to sustainability of the system.

Common design terms

It is useful to understand the following terms before attempting GFS design.
Head (static) is the elevation height of water
Head (residual) is the height after losses
Head (loss) is the height of reduced static head
Demand (peak flow) is a volume of water expected in a short period of time (2 - 6hrs)
Demand (average flow) is a 24hr volume of water
Flow (Q) is volume of water / second

Minimum design parameters

A GFS must consider the following components;

- elevated source of water; spring, creek, river, lake
- intake at the source and sedimentation
- main pipeline to the distribution network
- reservoir(s) for peak demand
- distribution network
- water points
- washout valves / air release valves / break pressure tanks (if required)

GFS Guidelines

- 20 year population growth
- 30 l / person / day,
- water point / 50 people,
- peak demand = 2 -6hrs,
- residual head between 5 and 12m,
- <1 NTU, 0 coliforms.
- Poly pipe is class 12,
- Pipe connections are class 16.

Design Procedure

There are many preferred ways of designing GFS. Because of an abundance of water in most PNG provinces and the daily routine of rural communities, it is useful to begin the design procedure by calculating the water demand of the population, then calculating the pipe diameters nearest to the users, working back to the intake (see TAN Tool 5.1 GFS Design with 6hrs peak demand)

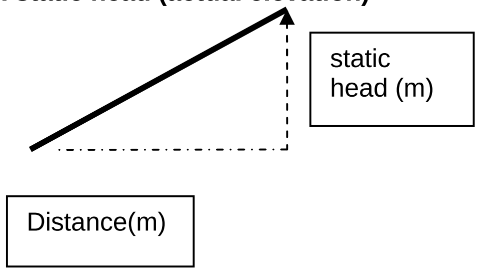
I. mapping distance and elevations from the source to the user; a map or sketch will indicate the components of the gravity fed system, distances, static heads (using GPS or clino-meter) and populations served.

II. design population; population growth over 20 years = current population x (1+ annual growth rate / 100)^{20}

III. peak flow demand per 6hrs; volume / 6hrs / 60 min / 60 sec = l / sec

IV. average flow demand per 24hrs; volume / 24hrs / 60 min / 60 sec = l / sec

V. static head (actual elevation)



VI Known values; distance of pipe routes, static head and population. Those values can determine the flow demand of each pipe.

VII. diameter of pipe; The friction head loss table determines the pipe diameters using the known values

VIII. residual head; subtracting the head loss from the static head gives the residual head

IX. other head losses; In rural GFS, the head losses caused by junctions and fittings in the system are mostly negligible.
X. reservoir storage; Storage = peak demand – peak demand / average demand.

Community management

There is an abundance of opportunity for communities to own and manage a GFS. NSAs must facilitate gender inclusion in decision-making from the very beginning (possibly using TAN Tool 5.6- Timeline – Women's Participation), and explain the GFS guidelines. The community can map the village against the guidelines and propose locations of different water points and their different uses. The community proposal can be much more than the allowed EU subsidy, and this can be the first step of a watsan committee plan for future infrastructure development. It is important that the community recognises the recurring costs of medicine relating to water related diseases before the project is implemented, because the GFS will improve health and reduce drudgery for women and children. The economic impact on the community will be immediate, and this factor should contribute to the community's willingness to pay tariffs to maintain the water supply.

Common mistakes

- Spring catchments and other intakes are poorly considered leading to less profitable exploitation of the water source. Sometimes the spring 'eye' is unnaturally diverted or is lower than the intake pipe (see TAN 4.91 Water Supply – Spring catchment).
- The flow of water can increase and reduce depending on the season or weather. This is sometimes not considered in the design.
- Rural Water Engineers in PNG continue to place the largest pipe diameter from the intake to the reservoir. This is mathematically incorrect to do so, as this pipe has flows over 24hrs. The first of the reticulation pipes to come from the reservoir is likely to be the largest diameter pipe, as this pipe has flows over a peak demand period (2 – 6hrs). Wrongly sized pipes in this part of the GFS, reflects upon the engineers understanding and confidence in their design procedure.
- Pipes are not fully buried. This has catastrophic consequences for the life-span of the system. black poly pipes expand and contract when left out in the open, and can be slashed by farmers.
- Inconsistent and interrupted flows occur at different water points, depending on the elevation from the reservoir. Geographical peaks and troughs in the terrain should have outlet valves to release air pockets and sludge respectively. Also, an air pressure release pipe can be included immediately after the outlet from the reservoir tank.
- Overflow pipes drain directly onto the foundation base of the reservoir tank, leading to subsidence and eventual collapse of the tank.
- Communities sometimes expect the NSA or main financial contributor to the project to return periodically to pay for, and effect repairs. The system has to be owned completely by the community, therefore maintained wholly by the community (see TAN 2.1 Community Management (Committees)
- Water points pool with water and cause drainage problems that are associated with vector disease. Each water point must include a drainage chamber of approximately $1m^3$.

Concluding comments

Mistakes in GFS projects can be avoided, and in particular, seasoned engineers in PNG must learn also to change their design methodology to suit development. GFS can be much more effective if the engineer allows community involvement in all aspects of the design. The engineer's unique skill is in following the design procedure only, to ensure maximised water flow and minimised maintenance. The clever aspect of the engineer's design is in the inclusion of the community, particularly women, in determining how and what the water points will be used for. Unless otherwise informed and educated, the community perception of the GFS will be a 'tap stands near to houses', and 'belongs to someone else' mentality. If this perception is not changed before construction, a significant number of opportunities for sustainability will be wasted. Pro-active community management of a GFS is much more beneficial to community development than a reactive watsan committee. NSAs must promote ownership of the GFS from community awareness and contributions, through design, and by training in community management.

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