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SUSTAINABILITY OF WATER AND SANITATION SYSTEMS

The use of the GPS system in the water sector

Henry K. Ntale, Uganda

GLOBAL POSITIONING SYSTEM (GPS) is a fairly recent technology which uses orbiting satellites to calculate any position on earth. Though it was originally conceived primarily as a tool for military Navigation, GPS use has gradually spread to civilian applications ranging from air traffic management, general sea navigation to general surveying. It is this latter application that can be utilised in the water sector.

Usually, considerable ground surveys must be undertaken before a particular water resource is developed. Conventional methods of surveying require a clear line of site between the stationary and the roving point. Often in rural tropical areas of Africa, intervisibility between survey points is difficult to achieve. GPS does not require intervisibility between survey points.

Applications of GPS in the water sector

- Gravity water supply schemes and general pipe network surveys. GPS system can be a very suitable aid in the survey and mapping of gravity water supply schemes. Design and 'as built' drawings become so easy to prepare using GPS technology. Maintenance of supply networks is also enhanced as all the system components can be easily relocated on the ground using GPS technology.
- General point relocation.GPS units can be used to log all positions of other water sources such as protected springs, hand dug wells and boreholes. This data can then be analysed to find out the density or coverage of a given area in terms of water supply. If the district water officer has this data, as well as a GPS unit, scheduled maintenance visits may be paid to each water source to ascertain its condition as the point sources are easy to relocate.

  Some organisations have sometimes complained about workers who claim materials for 'ghost' point sources such as springs or boreholes. Some greedy workers may even claim materials for a point source which was completed years back. With proper point relocation using GPS, the incharge officer could easily verify the materials requisitions vis a vis the ongoing and completed work in the field.
- There is an optional interface between GPS Units and Personal Computers, such that the data obtained can be incorporated in a modern Geographical Information Systems (G.I.S) for spatial analysis and smart presentation.
- GPS can also be used as a navigation aid. This can come in handy if a team is surveying a rural area of difficult terrain with no roads.

Accuracy of the GPS system

The United States Department of Defence, encrypted the GPS signals so as to restrict the absolute precision (in absolute mode) capability available to civilians to about 5m (0.005" accuracy in longitude and latitude fixing) when using hand held units (Chrzanowski A et al., 1983).

It should be stated that accuracy significantly depends on the type of equipment, the state of the ionosphere and the number of satellites observed. With some recent sophisticated GPS equipment it is possible to obtain accuracies of one part per million (1 ppm) in absolute mode. (Kennie and Petrie, 1993).

However, if the satellites are observed in a differential mode, relative positions with centimetre-level precision can be obtained. In a differential mode, two or more GPS receivers simultaneously receive signals from the same set of satellites. The resulting observations are subsequently processed to obtain the components of the inter station baseline vectors.

Comparison with terrestrial methods

The basic characteristics of differential GPS are compared with conventional Terrestrial methods in Table 1.

Table 1. Comparison of GPS and terrestrial technologies

Characteristics	*GPS** *(Deferential mode)*	*Terrestrial*
Typical uncertainty for relative positions	1 – 20cm	$\frac{\text{distance}}{10^5}$
Typical operating range	0.1 – 1000Km	0.1 – 20Km
Duration per base line (excluding transport and setup)	1– 2 hrs	Min to hrs
Number of persons required	1–2	2–5
Intervisibility requirement	No	Yes
Portable	Yes	Yes

* These values are heavily dependent on the equipment type. The ones quoted above refer to the "average" cost equipment.

The terrestrial techniques are at a disadvantage in that they are man power intensive, range-limited and require intervisibility between stations. Any one who has surveyed through a coffee or banana plantation knows how uncomfortable it is. A project can risk becoming unpopular because of the population complaints about destruction of food plants.

Bwera county is generally a hilly place. So, the constraint of the available water head was not there.

We went through the usual procedures of establishing a gravity supply, namely source identification, desk map studies, population mobilisation etc. When it came to actual pipeline routing and tap stand positioning, we were accompanied by village elders. In addition we went with a GPS unit. While placing the pegs for the tap stands, we ensured a distance of at least 300m between any two tap stands. This was easily achieved using a GPS unit regardless of the thick coffee plantations. One person removed the peg and took it closer to his house (so that the tap could be closer to his house). With the use of the GPS we were able to retrace the original position.

We could not measure in differential mode (because we had only one GPS unit) Hence the altitude was not accurate (±50m). We had to find levels between the established pegs using a normal tilting level. It took a short time because we knew the position of the pegs already, and hence we would pick the line of best intervisibility between the pegs.

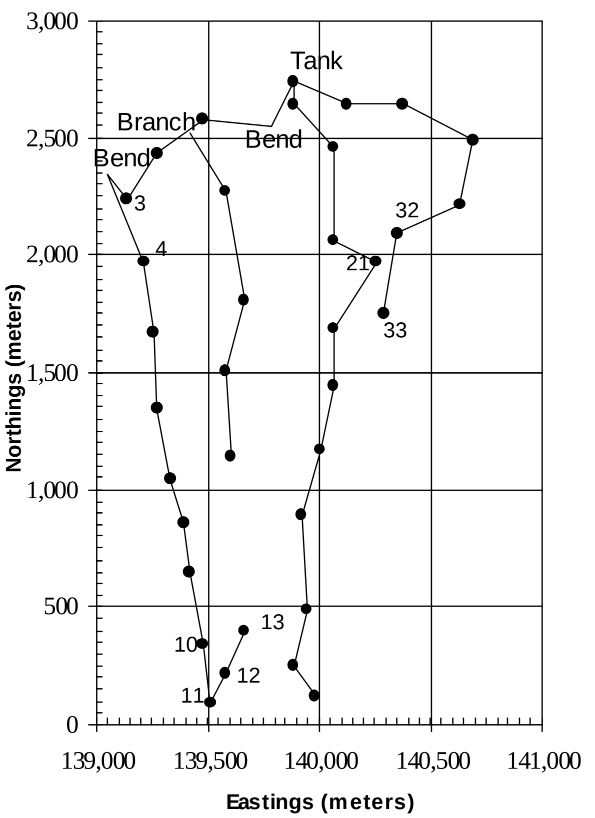

Figure 1. Bwera gravity supply scheme: Rusese Parish

After obtaining the levels, the network was designed and put in place.

To get an 'as built' drawing of the network, it was necessary to transform the Latitudes and Longitudes to Eastings and Northings. This was done using a computer programme.

When the 'as built' drawings in Figure 1 are examined several points can be made:

- Tap 21 could have been served better as a branch from line 32-33.
- Bend between Tap 3 and 4 could have been organised better.
- Line 12-13 should have been a branch from line 10-11.

Conclusion

Just as digital quartz circuitry revolutionised the science of time keeping, GPS Technology has revolutionised the process of position fixing. It is recommended that any organisation involved in Water Resources Development, be equipped with this new technology that is easy to use and effective. This shall greatly enhance the development of an up to date digital database of water resources which can be of great use to water engineers and planners.

References

Chrzanowski, A., Langley, R.B., Wells, D.E. and Maclaughlin J.D. (1983). "*A Forecast of the Impact of GPS on Surveying*" ACSM-ASP convention, Washington D.C.

Kennie, T.J.M. and Petrie, G. (1993). "*Engineering Surveying Technology*". John Wiley and Sons Inc. pp125 - 139.