# Enkanyezini and Kwangwanase rural water supply projects at Manguzi, near Kosi Bay

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## BACKGROUND

In early 2004 Jeffares & Green (J&G) was appointed by Aquamanzi Developments and Mhlathuze Water to prepare Department of Water Affairs and Forestry (DWAF) Version 3.3 Project Business Plans for the Enkanyezini Phase 2 and Kwangwanase Phase 3 Community Water Supply Schemes respectively. Both Aquamanzi Developments and Mhlathuze Water were acting as implementing agents for the uMkhanyakude District Municipality (UDM).

The two schemes are very close to each other and are hydraulically linked. They are therefore considered as one regional rural scheme, with all of the below referring to the elements of both schemes.

In 2006 J&G's appointments were extended to cover the implementation of both schemes, which are located within five municipal wards around the town of Manguzi in Maputaland, northern KwaZulu-Natal (KZN), and also extend from there up to the Farazella border post on the Mozambique border.

J&G's involvement in the scheme has therefore been from 2004 until September 2012 when the scheme was commissioned, operation and maintenance (O&M) documentation compiled, operator training carried out and the scheme handed over to the UDM.

Manguzi is near Kosi Bay, which is located within the uMhlabuyalingana Local Municipality, which in turn falls under the jurisdiction of the UDM, who is the Water Services Authority (WSA) for the district. The rural area around Manguzi also falls under the Tembe Traditional Authority under Inkosi M I Tembe and his Council. The scheme extends north-south for about 25 km, bordering on Mozambique in the north, and extends west-east for about 20 km, bordering on the Greater St Lucia Wetland Park in the east.

## AIMS AND OBJECTIVES

The existing Phase 1 of Enkanyezini and existing Phases 1 and 2 of Kwangwanase were implemented by others during the early and mid-1990s, and were designed to supply potable water to RDP (Reconstruction and Development Programme) standards to an estimated consumer base of about 15 000 people in 2004.

The estimated total population in the proposed supply area of this scheme in 2004 was about 58 000 people, therefore indicating a large backlog in potable water supply at that time.

The current scheme is designed to supply potable water to an estimated current population of about 73 000 people. This number is expected to increase to about 98 000 at the end of the 15-year design horizon, ending in 2022.

The main aim of the scheme is to supply safe, potable water to the local population in and around Manguzi town, and to also reduce the time spent by many of the womenfolk in the traditional and arduous task of collecting water, thus enabling them to play a more meaningful role in the economy of the area.

Other aims of the scheme were to provide temporary employment in the area, to boost the economy of the area and to leave as many technical skills behind as possible to improve the employment potential of community members.

## DESIGN CRITERIA AND PHILOSOPHY

The design criteria used were based on the Department of Water Affairs (DWAF) RDP Rural Water Supply Design Criteria Guidelines, First Edition, October 1997.

This essentially involved the supply of potable water to all consumers in the supply area via communal standpipes within a maximum one-way walking distance of 200 m from any homestead, at an average annual daily demand (AADD) of 25 ℓ/p/day. The infrastructure was designed for an AADD of at least 60 ℓ/p/day to allow for an improvement in the level of service over time to yard-taps or house connections, which had mostly already been achieved under the existing phases.

The supply area falls within the Makhathini flats and is generally very flat and sandy, with three main ridges of ancient vegetated dunes running north-south through the west and centre of the supply area, forming local water-sheds.

Raw water was sourced from 12 production boreholes, two perennial streams and a natural lake. Wherever feasible, this water was treated as closely as possible to its source to minimise the distance required to pump raw water, thereby minimising sedimentation accumulation in the pumping mains. After treatment the water is then pumped to storage reservoirs distributed along the water-sheds for distribution to communities under gravity.

Consideration was initially given to reinforced concrete ground-level reservoirs at some of these local high points, with elevated galvanised mild steel (GMS) tanks alongside, and elevated GMS tanks only at the other locations.

These locations are mostly very isolated and accessible only by narrow sandy tracks through thick coastal vegetation, making concrete reservoir construction using grade 35A/19 MPa concrete to standard very difficult, costly and time-consuming. It also meant constructing costly electricity supply infrastructure to these points to lift the water to the elevated tanks alongside.

J&G therefore decided, together with the project team, to elevate all storage at these points on either 10 m, 15 m or 20 m high GMS stands, as required, which would make reservoir construction by steel tank sub-contractors quicker and provide as much head above ground as possible at all these points, negating the need for localised pumping.

J&G decided to try and minimise pumping and pumping distances to these tanks as much as possible, and to maximise distribution under gravity from each elevated tank within its particular supply area.

HDPe pipes were used up to and including 90 mm dia with uPVC pipes being used for larger diameters. Although 90 mm dia HDPe piping was marginally more expensive than 90 mm dia uPVC, the HDPe piping could be laid quicker, with joints only every 50 m instead of every 6 m in a slightly lower grade of bedding material. It is also a more robust and appropriate material for this rural application.

In about mid-2006 Eskom imposed a moratorium on any further electricity supplies in the general area due to network constraints on their Makhathini line. This had serious implications for the scheme, which needed seven new supplies and five existing supplies requiring upgrading. Thankfully this moratorium was eventually lifted in early 2009, but obviously resulted in numerous delays with related costs.

Every effort was made by J&G to concentrate the need for electricity, for raw and potable water pumping, and for water treatment as closely as possible to main road R22 which runs through the middle of the supply area and through Manguzi to Mozambique. Eskom's line generally follows this route, which would minimise the extent of new Eskom infrastructure, thereby saving time and costs.

J&G focused the design and implementation philosophy of this scheme more on simplifying the long-term O&M of the scheme and related costs, through appropriate technology, and less on the short-term capital construction and related costs, although these were obviously an important factor. This was done by providing electrical and mechanical plant, and civil infrastructure of sufficiently high and appropriate quality and standard for ease of O&M.

During the various implementation stages of the scheme, efforts were made to try and involve the same reliable, experienced and locally (KZN) based service providers throughout (such as pump, electrical control panel and water treatment plant manufacturers/suppliers) to minimise the number and costs of role-players giving on-going support to the scheme during its operational life.

## PROJECT DESCRIPTION

### Technical

The scheme consists of the following main components:

- 318 km of HDPe and uPVC gravity and pumping mains, varying from 20 mm to 90 mm dia in HDPe, and 110 mm to 315 mm dia in uPVC
- approximately 1 350 valve and meter chambers
- 760 communal standpipes
- 17 elevated GMS tanks, varying in size from 45 Kl to 620 Kl net storage capacity on GMS stands 10 m, 15 m or 20 m high
- five ground level GMS or concrete reservoirs, varying in size from 100 Kl to 225 Kl
- 12 new or upgraded production boreholes
- two reconstructed stream abstractions and one reconstructed lake abstraction
- six small water treatment plants (WTPs), varying in capacity from 0.2 Mℓ/d to 2.7 Mℓ/d, which included substantial upgrading of the two existing plants
- five high-lift pump stations including electrical/mechanical pumping plant
- two main water offices and five satellite water offices
- security fencing, valve and meter chambers, road and stream crossings, repairs to existing infrastructure, removal of illegal water and electrical connections, security provision, etc
- incorporation of a GSM cellular phone monitoring system to monitor the drawdown and recovery of all boreholes in their respective well-fields and to also monitor all other relevant pumping equipment (this was done to provide an early warning system, should problems occur, to ensure that the appropriate level of O&M personnel, be it local operator or external service provider, would be alerted early to pumping-related problems, thereby minimising water supply interruptions).

### Institutional and social development (ISD)

Isango cc and Mokoatsi Community Development Services were appointed as ISD consultants on the Kwangwanase and Ekanyezini projects respectively to assist with the establishment of project steering committees (PSCs) and labour desks. The task of the latter was to facilitate the procurement of local labour for employment by the various contractors and sub-contractors.

The ISD consultants were invaluable in their liaison with all project role-players, including the Traditional Council, especially when it came to dealing with community structures, numerous costly and disruptive illegal water and electrical connections, vandalism, theft and general conflict and dispute resolution.

Ten Expanded Public Works Programme (EPWP) learnerships were involved in the early part of the scheme over three stages (starting in October 2006), with one contract per learnership per stage, in increasing budgeted values of R350 000, R500 000 and R1 000 000. These contracts essentially involved trenching, the supply and installation of pipes and fittings, the backfilling and compacting of the trenches, and the management of the contracts.

Learnership trainees had a separate mentor/trainer, and were also mentored through hands-on training by the two main civil contractors on each project, assisted by J&G's site supervision staff, comprising a Resident Engineer (RE) and two Assistant REs.

Wherever practical, labour-intensive construction methods were used, both in the learnership programmes and by the main civil contractors.

One of the advantages of working in the area was the soft sandy soils, which made hand excavation for pipe trenching easy and which negated the need to import costly pipe-bedding materials.

## PROJECT IMPLEMENTATION

The main civil contracts were awarded to Afriscan Construction Pty (Ltd) in March 2007 on the Enkanyezini Phase 2 scheme, and Hidrotech Infra Pty (Ltd) in August 2007 on the Kwangwanase Phase 3 scheme. These contracts were completed in March 2010 and June 2011 respectively.

Photo 1: Cyclone, buffer tank and pump station at stream abstraction showing pipe work and solenoid valve at cyclone base

The final phase of Kwangwanase, Phase 3 Extension, was to have commenced in July 2010, but due to various administrative delays, and a change of scope and procurement approach, eventually commenced almost a year later in June 2011.

Instead of a single contract as for the earlier phases, the contract was split into three, with the civil contract again being awarded to Hidrotech Infra Pty (Ltd), the electrical/mechanical contract to East Coast Irrigation and the pipes and materials supply contract to Thembamanzi cc.

Various sub-contractors were involved in the scheme, providing specialist services, such as the manufacture and/or supplying and installation of elevated GMS tanks and stands, pumping plant, electrical control panels and wiring, water purification plant, plant monitoring, etc.

Geotechnical, environmental and earth science consultants Terratest supervised the drilling of nine boreholes, of which six replaced existing collapsed or vandalised boreholes, and also sleeved two existing boreholes. Extensive drawdown and recovery tests on all boreholes were also done with water quality analyses being carried out by various accredited laboratories.

Of the 12 production boreholes on this scheme, four are located in the Airfield well-field and five in the Thengani well-field. The boreholes in each of these well-fields pump water through shared pumping mains to the Airfield and Thengani WTPs respectively. Due to the variations in depths of the unconfined aquifers, and the shared pumping mains and existing borehole casing sizes, positive displacement borehole pumps were used (not centrifugal pumps).

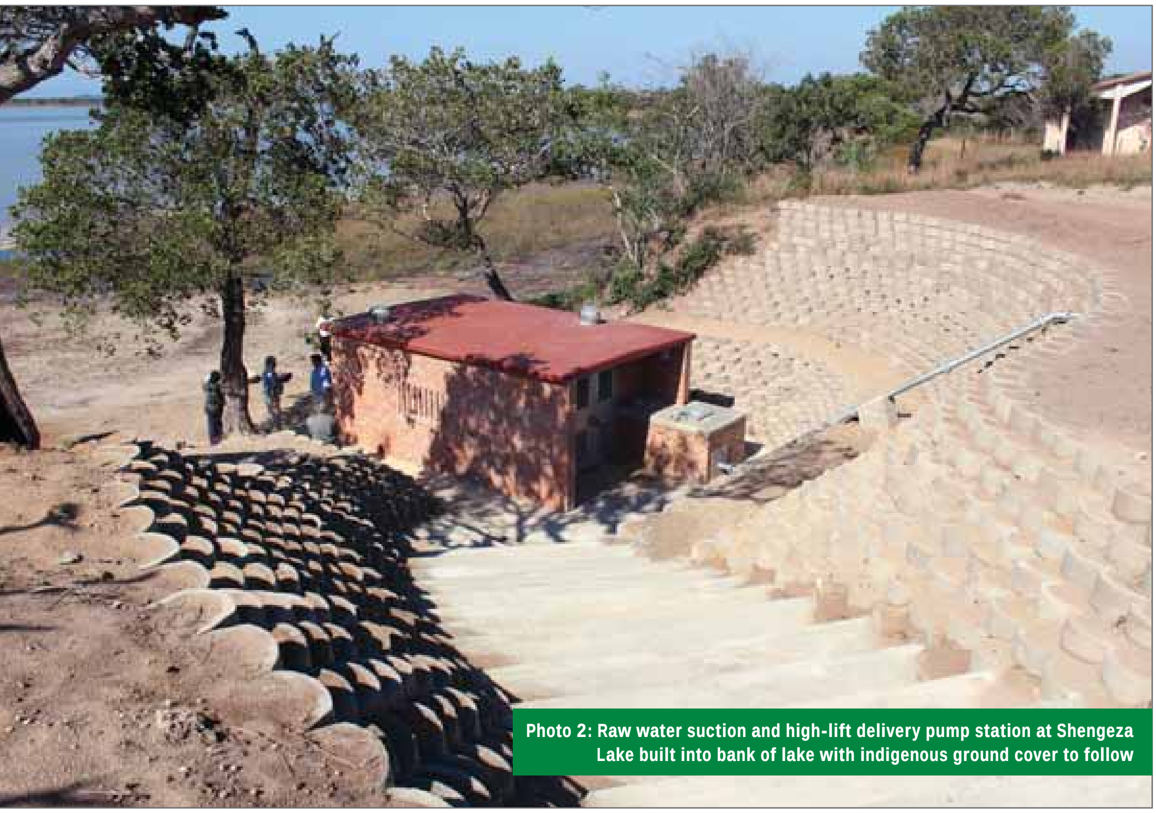

Photo 2: Raw water suction and high-lift delivery pump station at Shengeza Lake built into bank of lake with indigenous ground cover to follow

The turbidity, colour, iron and manganese determinants in most of the boreholes fell within Class 2 or Class 3 water, which is marginal-to-poor quality water, according to DWAF's criteria for drinking water.

The treatment for mixed water from these two borehole systems involved dosing with sodium hydroxide to increase the ph in the water, then with sodium hypochlorite to disinfect the water and oxidise the iron, then adding GR150 coagulant to destabilise the colloidal suspension in the water and improve the performance of the pressure filters in the plant.

Raw water at the Gezisa and Nkanini stream abstractions is pumped by a set of submersible pumps, in an abstraction chamber in each stream, tangentially into the top of a conical-shaped cyclone, or centrifuge, on each stream bank. The water swirls to the bottom of the cyclone and slowly rises in a chamber inside the cyclone, then flows out of a horizontal pipe in the chamber top to a buffer tank. This provides flooded suction to a set of high-lift pumps in the pump station alongside, to pump from there to the Manguzi or Enkanyezini WTPs.

An electrically operated solenoid valve on the cyclone scour is automatically opened for a second or two at regular intervals to flush any settled organic matter back into the stream, downstream of the abstraction point. The buffer tank can also scour into this drainage pipe when required (Photo 1).

The water quality from these perennial streams is generally good as they flow slowly through mostly indigenous vegetation in soft sandy soils. The treatment process after cycloning is flocculation, sedimentation, disinfection and filtration.

Another raw water source is the natural Shengeza Lake which forms part of the Greater St Lucia Wetland Park. Water is abstracted from the lake via a suction main comprising about 8 m of 150 m dia GMS pipe and 72 m of 180 mm dia stub-flanged HDPe PN16 pipe.

From the pump station at the lake's edge the suction main is buried below the lake shore over a distance of about 45 m. It then runs for another 35 m into the lake where it emerges through the lake floor, under the water, and runs 200 mm above the floor on concrete mooring blocks spaced at 3 m centres. The main terminates in a removable stainless steel intake screen positioned approximately 300 mm above the lake floor, and 1.5 m below lake water level. The intake screen is especially designed to allow both the intake of water and the return of water during flushing of the main.

Roughly 7 m from the pump station, along the suction main, is a non-return valve (NRV), situated between two short pipes, with inlet ports in a concrete chamber, which had to be sunk almost 2 m into the saturated lake shore, along with the main, by high-pressure water jetting.

Before the duty or standby pump starts in the pump station (see Photo 2), a solenoid valve allows water from the delivery main back around the pumps into the suction main between the pumps and the NRV to prime the pumps. The duty pump then starts with the solenoid valve remaining open for a few minutes to ensure full priming. After the pump stops, another solenoid valve opens and allows water from the delivery main back around the pumps into the suction main between the NRV and the lake to flush the main for a few seconds.

When the next pump cycle starts, using the alternative pump through a flip-flop switch to balance pumping hours for each pump, the process repeats itself.

No sooner had this system been installed in the lake and tested, when a family of curious hippos took up residence near the inlet screen, probably being attracted by the sound or vibration, but thankfully so far not appearing to have damaged anything. Hopefully hippos are as careful where they place their feet as elephants!

Due to indigenous vegetation, algae, wave action from onshore winds and the presence of hippos, the lake water is often very turbid. The positive displacement abstraction pumps are especially designed for the lake's pumping conditions and raw water quality, and pump in a single lift from the lake directly to the Manguzi WTP (Photo 3) about 6 km away.

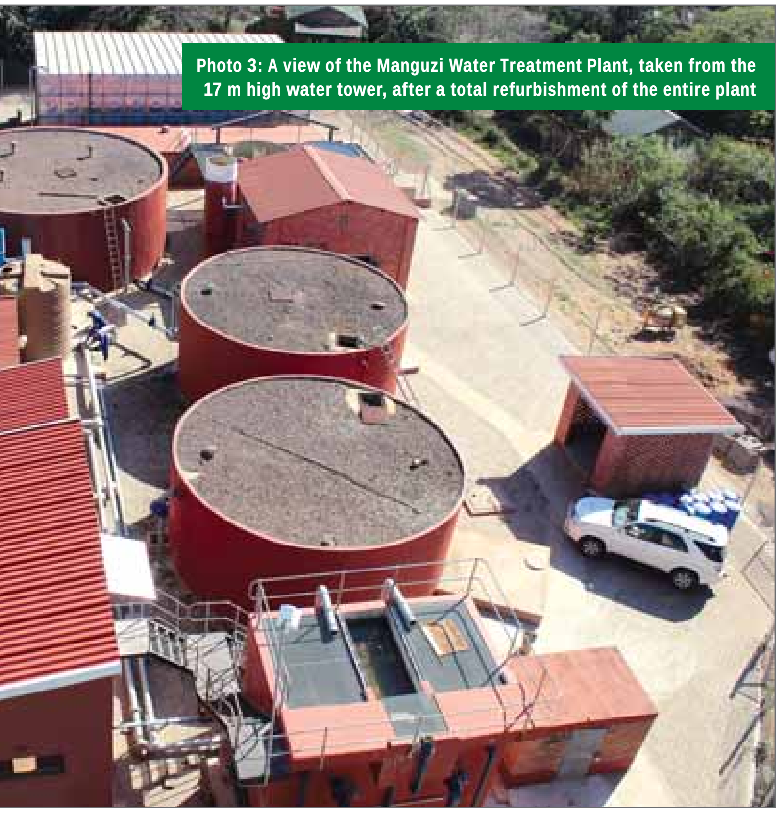
Photo 3: A view of the Manguzi Water Treatment Plant, taken from the 17 m high water tower, after a total refurbishment of the entire plant

At the WTP, flocculant is added to the water, and it then runs through a dissolved air flotation (DAF) unit where air under pressure is injected into the water. The scum then floats to the surface and is skimmed off with brushes drawn over the unit by nylon chains. The water then passes through a rapid gravity filter and is disinfected before entering the final water reservoir.

The *Franklin Wells for the World Foundation* was also involved in the scheme by part-funding the small water supply project at Inkosi Tembe's traditional homestead at Emfihlweni, where treated borehole water is reticulated from elevated storage to the homestead, two schools, a mobile clinic point and the local community.

## CHALLENGES AND RISKS

The main challenges and risks/threats to this scheme are as follows:

- The current capacity of the WSA to effectively O&M the scheme with sufficient resources and funds.
- The scattered settlement patterns of the benefiting communities, resulting in a high per capita cost, with the potential of making the scheme unsustainable in the long-term, unless a cost-recovery plan is implemented.
- The vulnerability of all reticulation mains not being easily identifiable or 'protected' within registered servitudes, resulting in their ease of access for potential vandalism or illegal connections.
- The current capacity of Eskom's electrical supply to the area. Frequent outages, planned or otherwise, are currently experienced, and frequent fluctuations in the voltages of the three incoming phases are also often experienced. This should hopefully improve when/if the line is extended south to Mbazwana, forming a link back to Eskom's network.
- The large number of illegal water and electricity connections in the area.
  - Illegal water connections are often made off dedicated pumping and gravity mains, from which no connections must be made, thereby affecting flows to critical destinations.

Illegal connections are normally cheaper than legal ones but are generally sub-standard, resulting in numerous leaks. There are indications that some locals ran small businesses selling water prior to the commissioning of this scheme. The scheme now affects their livelihood, resulting in acts of vandalism to infrastructure to maintain their income.

- Illegal electrical connections (mostly by someone who appears to know exactly how to tap into the supply) are numerous and often very dangerous. These are normally off only one phase at a supply point, which can lead to phase imbalance and resultant damage to pumping plant. Eskom has contracted a specialist team to remove illegal connections, but for various reasons it is very difficult to prosecute offenders, so this vexing problem continues unabated.

- Numerous incidents of vandalism and theft, leading to additional security costs being incurred. The provision of sets of keyed-alike padlocks for all valve and meter chambers, structures and buildings cost in excess of R400 000!
- There were also various incidents of hijackings or attempted hijackings directed at the project team, due to the close proximity of the scheme to Mozambique.
- The vulnerability of the groundwater aquifer, due to population densification, the development of Manguzi as a growth point, the planting of gum plantations as a source of income, pollution, etc.
- The generally flat topography, consisting of small undulating vegetated coastal dunes, required elevated storage at virtually all storage points, and also required a very large amount of air and scour valves to properly vent and scour the system along these undulations.

J&G considered various systems for abstracting water from the two streams and the lake. These systems had to be able to deal with often turbid water with hard or soft solids in suspension of varying shapes and sizes. They had to be low maintenance due to their remote locations, with as many visible components as possible (as opposed to a buried sand abstraction system at the lake), making the identification of problem areas or faulty components easier – especially in the presence of hippos in the lake!

## SCHEME COSTS

The total cost of the Kwangwanase and Enkanyezini rural scheme is R164 688 920. Of this amount, R26 636 590 (16.2%) covers the indirect costs of consultants, implementing agents and the community. A total of R138 052 330 (83.8%) covers the direct costs of construction by contractors, sub-contractors, learnerships, etc. *Franklin Wells for the World Foundation* donated an additional approximately R260 000 towards a small stand-alone section of the scheme, bringing the total scheme cost to almost R165 million.

## CONCLUSION

With all its various facets, this rural scheme has, over the last eight years, been very interesting and challenging, both technically and socially. Most of the challenges mentioned above can be expected on any rural project in South Africa. The ultimate aim of the scheme is to provide safe, potable water to consumers, which will contribute towards an improvement in their quality of life. Hopefully this has been achieved, and it will now depend on the WSA, the benefiting community and other relevant role-players to take full ownership and responsibility for the scheme to ensure sustainability for their mutual benefit. □

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-October/#/0