Water Supply Situation in the Western Highveld Area

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SYNOPSIS

The Western Highveld area is located some 100 km north east of Pretoria and supports a population of approximately 650 000, most of whom live in peri-urban areas Water is currently supplied to the area from two main sources namely the Weltevreden and Bronkhorstspruit water purification plants which supply 60Ml/day and 40 Ml/day respectively providing a daily supply of 100 Ml/day.

The water supplied to the area appears to be sufficient during the cooler winter period and during the hot summer months severe shortages occur. The problem has been the subject of numerous studies over a period of many years and to date, relatively little progress has been made in addressing the problems.

The Department of Water Affairs and Forestry has undertaken several studies to investigate the possibility of supplying additional water resources to the area by commissioning a new water transfer scheme. Although such a scheme is possible and could be completed within a few years, it is prohibitively expensive. Before investing several hundred million rands on a new pipeline it was decided to investigate the true magnitude of the problem and assess if there is any scope for utilising the current resources more efficiently in line with the latest government guidelines on all new water related developments.

A study was recently commissioned by the Department of Water Affairs and Forestry and undertaken by a group of water conservation specialists to assess the water supply situation in the Western Highveld area and to evaluate the water demands. The study was completed towards the middle of 2003 and the findings are very interesting and clearly indicated that the current water supply should be more than sufficient to supply the total population without further augmentation. Through further investigation it became apparent that the water shortages during the summer period are caused by excessive water use and losses in certain areas including irrigation for gardens and small-scale agriculture. The high water use in certain areas results in water shortages in other areas which in turn have to be supplied using water tankers.

The situation in the Western Highveld area is similar to many other areas throughout South Africa where the problem of low payment levels is coupled to the use of potable water for small scale garden irrigation. The cycle of poverty is almost impossible to break in such areas and to date the problem in the Western Highveld area has yet to be solved although the background to the problems is now better understood. Until the issue of non-payment for water is addressed, many residents in the Western Highveld area will continue to rely on water tankers during the summer months because other residents are abusing the available potable water and using it for irrigation purposes.

The problems in the Western Highveld area raise some very important questions in cases where residents are living below the poverty line and using potable water to grow vegetables in order to survive. It was found, however, that the major source of water use was not in the low income areas but rather in the high income areas where residents were using the water to irrigate their lawns and not for food production.

INTRODUCTION

According to the most recent information (supplied by BIGEN Africa, October 2003), the Western Highveld area (**Figure 1**)supports a population of over 650 000 who receive water at varying levels of reliability from the Weltevreden and Bronkhorstspruit water treatment works (WTW).

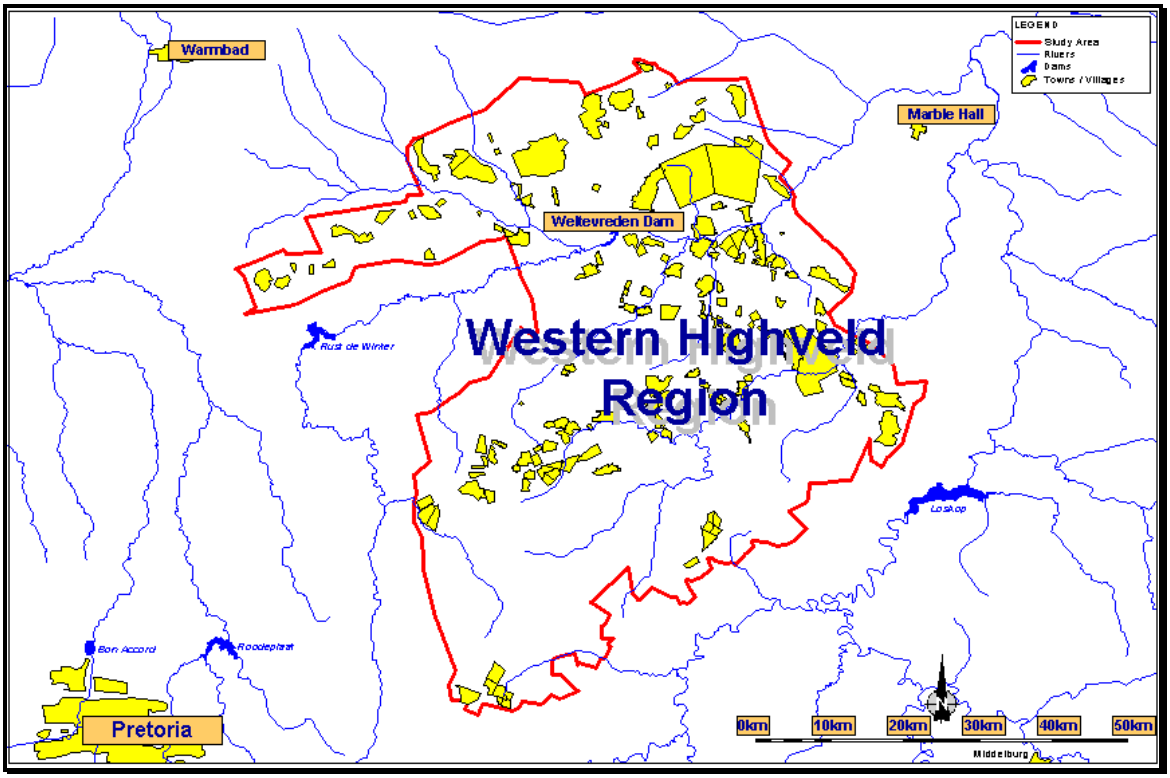

Figure 1: Map of the Western Highveld Area

The breakdown of residents served according to the different supply systems and levels of service is provided in **Figure 2**.

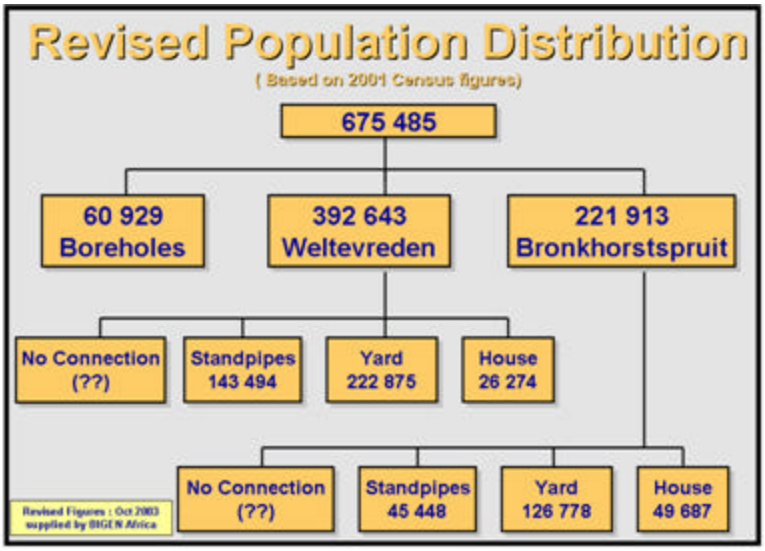

Figure 2: Level of service in the Western Highveld area

As can be seen from **Figure 2**, the majority of residents receiving formal water supplies (almost

90%) are either supplied from yard connections or standpipes. Less than 12% of the population served receive water through formal internal house connections,

The Problem

The water supply to the Western Highveld area is limited by various constraints including the treatment capacity of the two Water Treatment Works as well as the yield limitations from the two main supplying reservoirs, namely Bronkhorstspruit and Weltevreden. These two Water Treatment Works typically supply a total of 100 Ml/day with the split as shown in **Figure 3**.

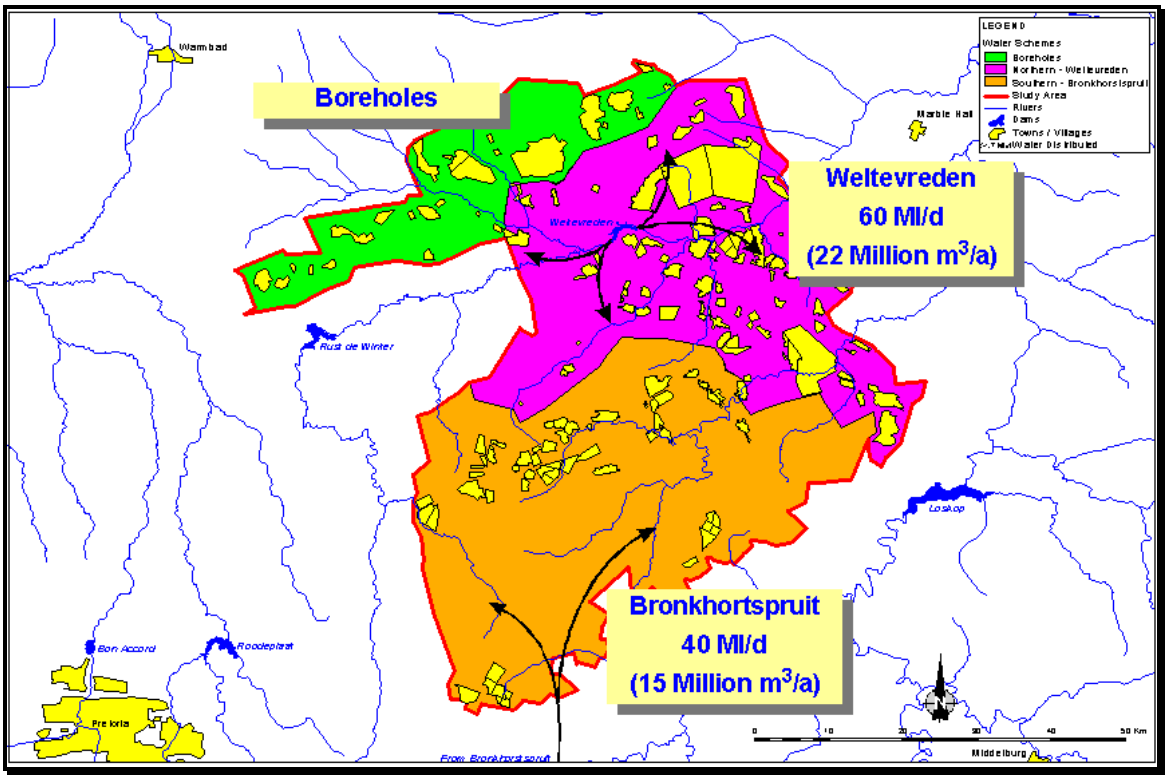

Figure 3: Western Highveld – Supply Zones

Each year during the hot summer months there is a severe water shortage which results in many residents being cut-off for days and even weeks at a time. Numerous studies have been undertaken by the Department of Water Affairs and Forestry to investigate the problems and the viability of increasing the water supply to the area. Before any new water resources are developed, however, the Department of Water Affairs and Forestry has made it clear that the existing resources must be used effectively and efficiently. In this regard, the Department commissioned a study in 2002 to assess the efficiency of water use in the area and to determine whether or not the available water supplied to the area is sufficient to meet the needs of the residents. The remainder of this paper presents a summary of the findings from the study from which it is shown that water is being abused in some parts of the project area to the detriment on many residents. The situation in the Western Highveld area is not unique and the same conditions occur in many other parts of South Africa.

Estimation of Water Demands

One of the first issues addressed in the study concerned the assessment of the water demands in the area. Considerable work in this regard has been undertaken in many previous studies and based on the results of such work it is possible to estimate the average water use per person per day for the various different levels of service.

One of the most important steps in the project was to confirm the population figures and to estimate the water demands for each community served with water in the project area. Initially there was considerable debate concerning the population figures with estimates from previous work as high as 1.05 million. After further detailed investigations by various consulting teams on behalf of the Department of Water Affairs and Forestry it appears that the actual population served in the area is closer to 650 000 as indicated previously in **Figure 2**. The figures quoted are based on an assessment by Urban Econ for DWAF and were processed into the format used in this paper by BIGEN Africa, also as npart of an ongoing study for DWAF. A breakdown of the population figures for the various areas covered by the different studies are shown in **Figure 4**.

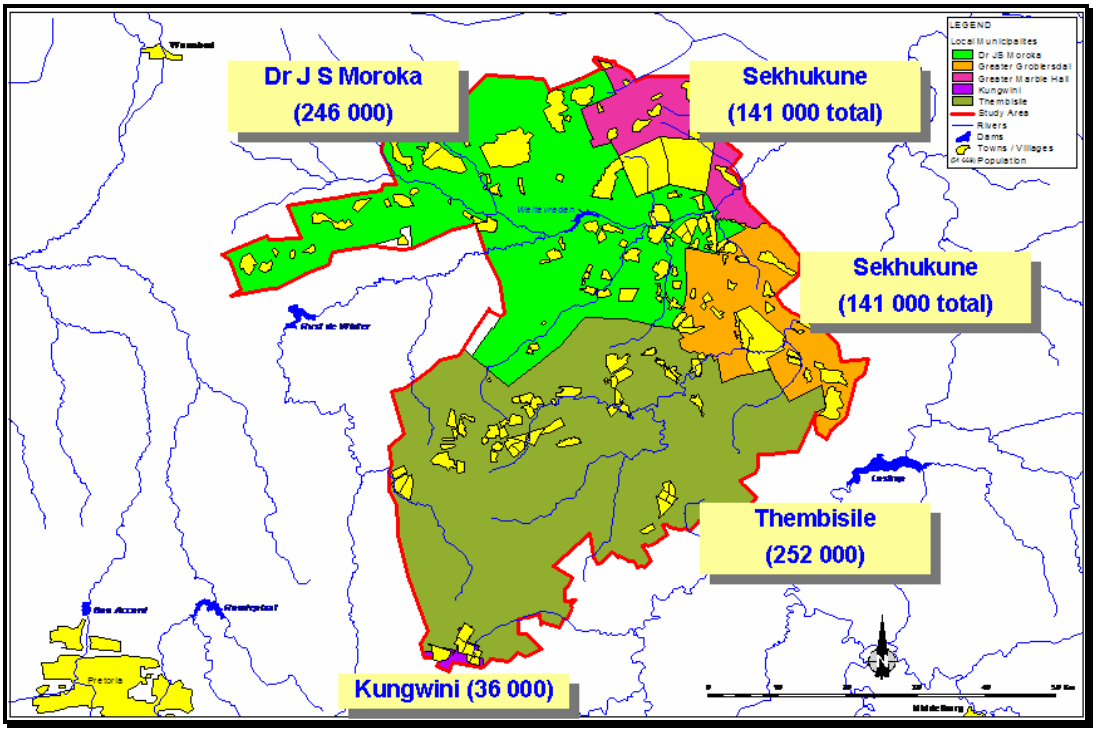

Figure 4: Map showing population figures as well as Urban and Peri-Urban Areas

Based on the population figures and the levels of service, the normally accepted water demands were estimated using the standard design per-capita consumptions which are normally considered to be generous and overestimate the actual water use. The initial results from the demand assessment are shown in **Figure 5**. From this figure it can be seen that the total water demand for the area is estimated to be in the order of 47.6 Ml/day. This figure allows for 6% treatment losses and 17% conveyance losses which again are considered realistic if not erring on the high side for the project area. It should be noted that most of the pipe-work in the area is relatively new in which case the unavoidable leakage from the system should be relatively small. This initial water demand assessment suggests that there is ample water being supplied to the area (100 Ml/day) and that there should in theory be no supply problems. In reality, however, the situation is very different and many thousands of residents experience problems on a regular basis during the summer months.

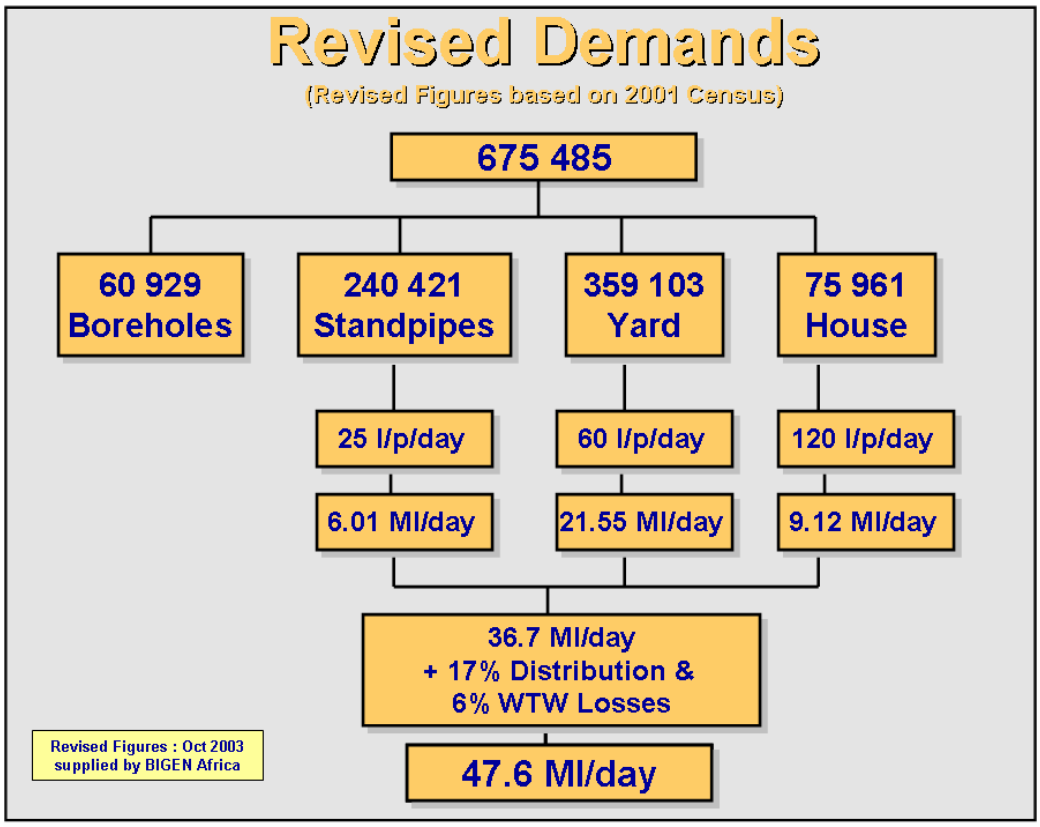

Figure 5: Estimated Water Demands for the Western Highveld Area

Identification of the Problem

Clearly with an average daily supply of 100 Ml/day, the water being supplied to the Western Highveld area should be sufficient to provide all residents with an uninterrupted water supply throughout the year. In the summer months, however, severe water shortages occur in many areas resulting in the need to use water tankers to carry water to many outlying and high areas which do not receive even the basic constitutional allowance. Clearly the actual water use in the project area is not being reflected properly and the key objective of the initial DWAF study was to identify where the water was being used and who was using it.

From visual inspection of the project area it was clear that some communities had ample water at their disposal while nearby others had no water at all. To measure the water use the project team undertook a series of flow measurements at selected points which could then be compared to the theoretical water use. The results from this exercise were both surprising and enlightening as they clearly highlighted the main source of the problem in the study area – that of blatant and deliberate abuse of water for gardening purposes. Some of the results are shown in **Figures 6 and 7** for two of the areas investigated where very high night-time use was observed.

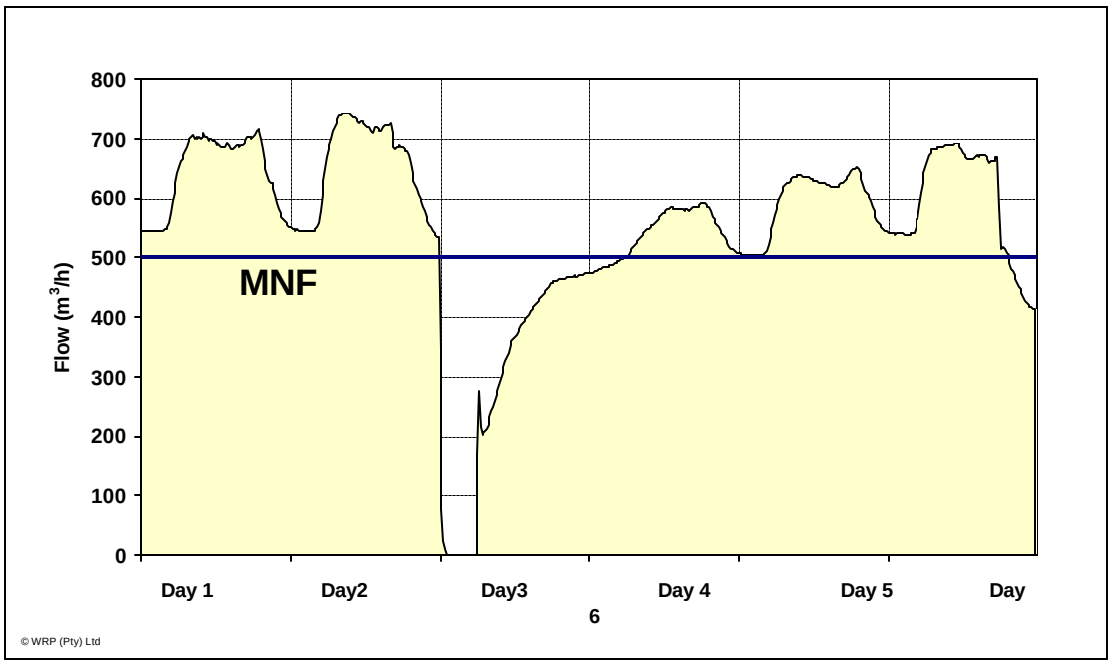

Figure 6: Flow measurements in Siyabuswa Flow (m^3/hr)

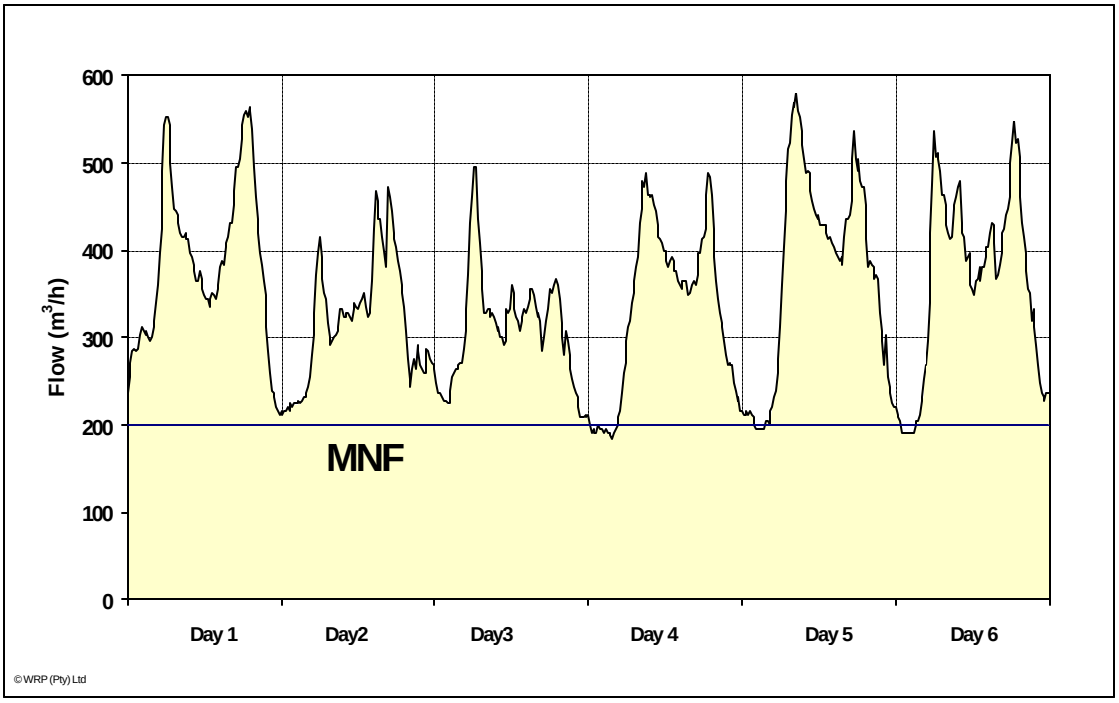

Figure 7: Flow measurements in Ekangala Flow (m^3/hr)

Figures 6 and 7 show the flows entering the two areas over a period of several days. It is important to identify and analyse the Minimum Night Flow (MNF) which represents the minimum flow entering each area during the period of minimum demand which is normally between 12 midnight and 4 am. The magnitude of the MNF is a very useful indicator of leakage and/or illegal use and in the case of these two areas, a MNF value of between 20 m^3/hr and 30 m^3/hr would be expected.

From the analyses of the figures it is clear that the MNF's are significantly greater than the expected

value indicating abnormally high night-use and/or leakage. Having identified certain areas of exceptionally high water use, the next step in the investigation was to identify the cause of the high MNF's.

Preliminary Analysis of Minimum Night Flows

The water supplied to an area during the period of lowest demand is termed the Minimum Night Flow (MNF) and typically occurs at approximately 2am when most consumers are asleep. The magnitude of the NMF is one of the most useful indicators of leakage and wastage in a water supply system. A typical well managed system will experience a MNF value in the order of 10% to 15% of the average daily demand.

The areas using and/or abusing most of the water all have internal plumbing and tend to support the more affluent section of the community. Most of the houses are well built and well maintained often with luscious gardens, supported it would seem by 24-hour irrigation in many cases. In order to identify the split between garden irrigation and internal household leakage the sewage returning to the sewer system was monitored. Such investigations are very useful and can identify many key problems. In some parts of South Africa, the tap and toilet leakage can account for more than 80% of the total night flow (Mckenzie, 2002)

The night flow of 500 m^3/hr shown in **Figure 6** is extremely high and represents 12 Ml/day or 12% of the total water supplied to the whole of the Western Highveld area (not just the Siyabuswa area). Such leakage/wastage is unacceptable in any area and particularly in areas where some consumers receive no water. **Figure 7** also shows a very high night flow which is lower than that shown in the previous figure but remains extremely high and indicates high leakage or wastage.

In the case of the Western Highveld area, it proved difficult to measure the sewerage return flows although some preliminary results were obtained which suggested that the internal plumbing losses in the order of 30% of the MNF. Although 30% is significant, it is not the main cause of the high night-time use and the team were able to conclude that most of the water being used was through the irrigation of gardens or burst pipes in the reticulation system since such use does not return to the sewer network.

From the visual inspections of the area, some burst pipes were identified, however, the main culprit was clearly the garden irrigation. Some typical examples of the water use/leakage are shown in **Figures 8 and 9**.

Figure 8 Leaking Tap

Figure 9 Lawn Watering during periods of water shortage

Figure 9 , shows garden watering in one of the more affluent areas while only a few kilometers away the residents have no water in their systems and have to rely on daily supplies carried by water tanker. The cost of the tanker water is estimated to be in excess of R50/m^3 compared to a cost of approximately R3/m^3 for the normal reticulated water. It should also be noted that the payment levels for the water in most areas can be considered to be zero with the result that the acting water service provider, Ikangala Water, is effectively carrying the full cost of both the reticulated water as well as the water supplied by a fleet of water tankers. The other way of looking at the situation is that those watering their gardens are effectively using water that is costing R50/ m^3 to replace.

Short Term Regional Intervention Project

In order to undertake further investigations and physically address some of the water supply problems in the Western Highveld Region area, a study was commissioned in 2002 to develop a water conservation and water demand management strategy for the area. One of the key recommendations from the study was the commissioning of a pilot intervention project to reduce the wastage in these areas and to demonstrate the effectiveness of various Water Demand Management (WDM) measures. In this regard, DWAF proposed the implementation of a Short Term Regional Intervention Plan (STRIP) in the Western Highveld Region. The project was funded by the Mpumalanga Provincial Government and the Department of Water Affairs and Forestry and involved the following ten Tasks:

Task 1: Consultation with stakeholders and political champions

Task 2: Distribution Management

Task 3: Comprehensive communication and awareness campaign

Task 4: Establishment of customer care centres

Task 5: Water use restrictions

Task 6: Identify and repair of distribution and plumbing leaks

Task 7: Setting and monitoring demand targets

Task 8: Pressure management

Task 9: Metering and billing of all large commercial and industrial consumers

Task 10: Identification and restriction of unauthorised commercial irrigation

In view of the large size of the whole project area and the limited budget available, it was agreed to concentrate the efforts in making a noticeable impact in certain key areas where the levels of

wastage were judged to be very high. In this regard, the following three areas were selected:

- Siyabuswa (Dr JS Moroka);
- Ekangala (Kungwini);
- KwaMhlanga (Thembisile).

While the different tasks were addressed by several different teams, the 2nd and 8th tasks were grouped and undertaken by the same team. The remainder of this paper provides some details of the distribution management and pressure management tasks.

Distribution Management

Distribution management is a basic element for the successful operation of all water distribution systems. In most cases, the water utility responsible for an area has all basic drawings and information concerning the area of supply. Basic drawings showing the pipe locations, sizes, positions of valves etc are a pre-requisite to the proper operation of any system. In the case of the Western Highveld area, it was found that the basic information was not available. At the start of the project, the water utility could not operate or manage the system properly due to a lack of reliable information on the reticulation system.

In order to help remedy the situation, the project team embarked on an exercise to facilitate proper distribution management. While such efforts do not result in immediate savings in water or reduce the minimum night flows, they do represent a meaningful and valuable contribution to the long term management of various sections of the system. By starting at the basics and trying to develop drawings etc, the project team has demonstrated what the water utility should aim to develop for each element of the reticulation system. By working closely with the personnel from Ikangala Water, the project team has tried to develop the necessary information and drawings needed to operate the system properly. It is hoped that the water board will carry out similar actions on their own in future to cover the remainder of the system.

The main actions undertaken under the distribution management task included:

- Collection of zone data and drawings;
- Evaluation of bulk mains;
- Evaluation of main valves and leak detection exercise;
- Evaluation of zones;
- Evaluation of unaccounted-for water.

While the above items may seem simple and straightforward, they are extremely time consuming and require considerable specialist input from the project team.

Pressure Management

Most water reticulation systems are designed to provide a minimum pressure at all points in the system throughout the day. This means that the minimum pressure (normally specified in the local by-laws) occurs at some critical point in the system which is often either the highest point in the system or the point furthest from the supply.

Water distribution systems generally experience significant fluctuations in demand throughout the day, with morning and evening peaks with periods of low demand during the night (sometimes also during the early afternoons). Many systems also experience seasonal fluctuations caused by climatic factors which influence irrigation requirements (garden watering in the Western Highveld area) that can significantly influence the demand for days or weeks at a time.

Since the water supply systems are designed to provide a set minimum pressure throughout the day, they are generally designed to meet this pressure requirement during periods of peak demand when the friction losses are at their highest and inlet pressures at their lowest. As a result of this

design methodology, most systems experience higher pressures than necessary during the remaining non-peak demand periods. This is evident from the fact that in most areas the major burst pipes tend to occur during the late evening and early morning periods when system pressures are at their highest. If excess pressure in a system can be reduced, then so too can the leakage, which in turn will save money. This basic approach is often referred to as "Active Pressure Control" or "Advanced Pressure Control".

Results

The project was completed in August 2003 and 6 new pressure management installations were commissioned. Since these installations were constructed, certain water restrictions have been imposed due to the identification of problems with the raw water resources which have dropped to critical levels due to the dry conditions experienced in the area over the past two years. As a result of the water restrictions, it is not possible to monitor the success of all 6 installations and **Figure 10** and **Table 1** show the results from Siyabuswa A which is one of the installations that still has continuous supply.

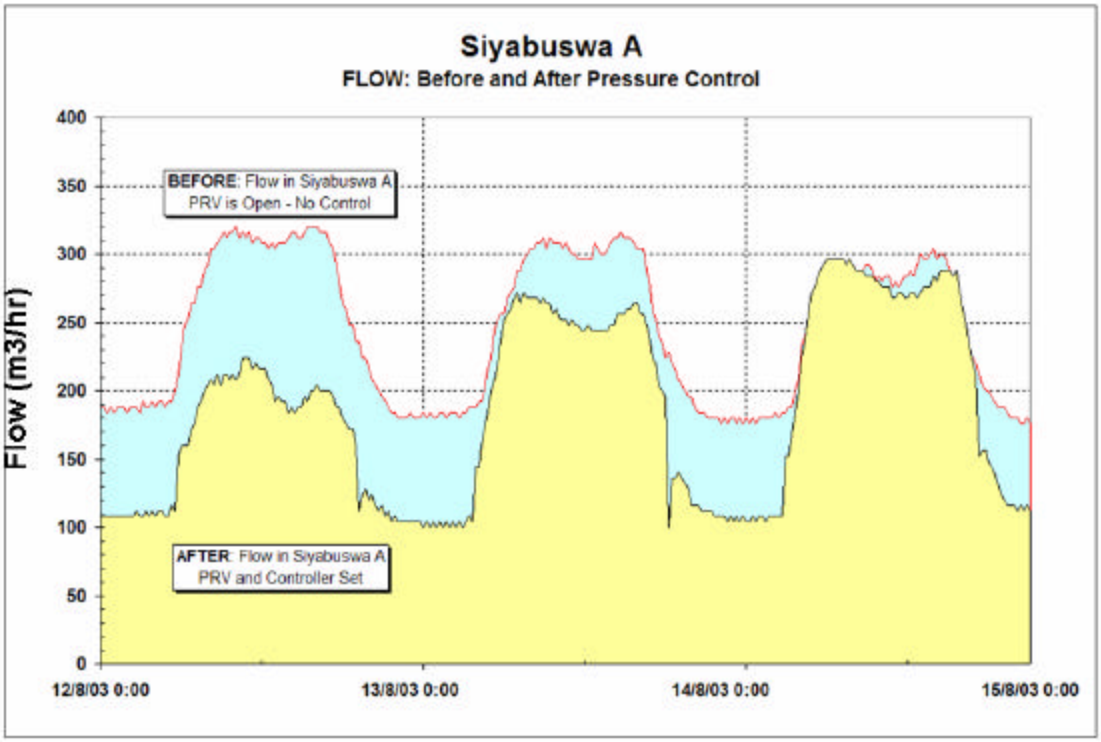

Figure 10: Water savings in Siyabuswa A through pressure management

Table 1: Initial savings through fixed outlet pressure control in Siyabuswa A and B

Area	Reduction in Minimum Night Flow	Saving per month (kl)	Saving per Month (Rand)	Saving per Year (Rand)
Siyabuswa A	44	26 000	60 000	716 000
Siyabuswa B	20	12 000	27 000	325 000
Totals	**64**	**38 000**	**87 000**	**1 041 000**

Summary and Conclusions

The situation in the Western Highveld area is extremely complex and there are many issues to

consider both social and political. It is therefore very difficult to summarise the full water supply situation in a few pages, however the following conclusions can be drawn:.

- The water supplied to the area should be more than sufficient to meet all existing demands;
- It is clear that water is being wasted in many areas through indiscriminate and unacceptable garden watering where residents simply leave hoses and sprinklers running continuously.
- Residents in many areas are using potable water for small-scale farming activities with the result that many other residents receive no water;
- Many residents are by-passing water meters through illegal connections, many of which appear to be professionally installed;
- Initial indications suggest that pressure management is highly successful in curbing wastage in selected areas;
- The general condition of pipe mains and valves seems to be good. Leaking valves and pipes were reported but were much lower than originally expected.

In conclusion, the water supply situation in the Western Highveld area is rapidly becoming critical and widespread water restrictions may soon be necessary if the storage levels in the main supply reservoirs continue to drop as they have done for the past two years. Unless prompt and decisive action is taken, the situation may deteriorate to the extent that water tankers become the primary source of water for many residents.

Clearly the residents must act together as a community and stop using water for irrigation purposes with immediate effect. They should report any water leaks and adopt a water saving approach to their daily lives.

Acknowledgements

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