The Development of Procedures for the Control of Unaccounted-for Water in Water Distribution Systems and for the Reduction of Water Loss

W de Vallier and D W Broadhurst

WRC Report NO. 489/1/97

DE LEUW CATHER (NORTH) (Pty) Ltd

Report to the

WATER RESEARCH COMMISSION

on

THE DEVELOPMENT OF PROCEDURES FOR THE CONTROL OF UNACCOUNTED-FOR WATER IN WATER DISTRIBUTION SYSTEMS AND FOR THE REDUCTION OF WATER LOSS

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PRETORIA

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EXECUTIVE SUMMARY

1. Introduction

In 1989 Mr HC Chapman attended the International Water Supply Association (IWSA) biennial conference in Copenhagen as the South African national rapporteur on unaccounted-for water (UAW). It became evident that South Africa was lagging behind world trends in UAW control.

In 1991 it was estimated that the UAW in South Africa amounted to 20% of the total urban and industrial demand or 800 Gℓ/a.

2. The Research Project

In reply to a research proposal submitted by De Leuw Cather (DLC) to the Water Research Commission (WRC), the WRC appointed DLC to undertake this research project with the following specific objectives in mind:

a) To establish the status quo of Unaccounted-for Water (UAW) measurement and its quantification by water distribution authorities in the Republic.

b) To determine the approach and means currently employed in practice to quantify UAW and identify its components.

c) To develop a measure for the quantification of UAW which will be absolute so that it could be used for direct comparison of systems performance.

d) To develop procedures for the identification, and quantification where appropriate, and control of the contributing components of UAW.

e) To develop procedures to facilitate the evaluation of the benefit/cost of the control procedures.

f) To determine the mechanisms and causes of leak formation and to investigate and propose methods for the prevention or reduction of leaks.

Subsequent to the inception of the Project, Mr Chapman pointed out that item (f) above was being addressed by a separate WRC project undertaken by the CSIR (Mattek) and the Water and Gas Department of the Johannesburg City Council. After discussion by the Steering Committee it was agreed that item (f) above should be replaced with the following:

f) To compile a comprehensive UAW manual, with supporting software, for use by water distribution authorities.

3. Summary of Research Results

The more pertinent results of the research are summarised as follows:

a) Few Local Authorities have comprehensive structures in place to deal with the control and reduction of UAW. Most Local Authorities use reactive rather than pre-emptive procedures for leakage control, replacement of consumer meters, etc., without addressing any of the other UAW components at all.

b) UAW is defined in various ways by different Local Authorities leading to inconsistencies in the data recorded by the Local Authorities.

c) Traditionally, the Treasury Department of a Local Authority is responsible for the reading of consumer meters. This results in further anomalies when consumption data is compared with total supply records.

d) Invisible leaks within a distribution system are probably the most signification component of UAW.

e) Inaccuracies in and incorrect sizing of water meters, especially with regard to bulk and large consumer meters, can be a significant component of UAW. Errors in the reading of meters and account processing exacerbate the situation.

f) The rapid urbanisation experienced in South Africa since the late 1980s has significantly increased the number of unmetered consumers. The establishment of informal sttlements and the regular occurrence of illegal land invasions has resulted in a significant increase in theft and unauthorised use of water.

g) The lack of detailed records on a national basis has made it impossible to estimate with any degree of certainty what the national UAW is. The conditions described in item (f) above have furter compounded the problem of determining a national UAW figure.

4. The UAW Manual

The UAW Manual had been prepared as a stand-alone document for distribution to and use by Local Authorities. With the current preparation of the SABS Code of Practice for the Management of Potable Water Distribution Systems (CoP) it became evident that the two documents, although complementary to each other, would result in a substantial amount of duplication if published as separate documents. At the request of the CoP Committee and with the agreement of the WRC it was decided to combine the UAW Manual with the CoP to produce a comprehensive document covering all aspects of water management in distribution systems.

The UAW Manual in the form that it was handed over to the CoP is, nevertheless, published in the interim by the WRC as Technology Transfer Report number 93/97.

5. Recommendations

With the recent introduction of the National Water Supply Regulations and the imminent publication of the CoP it is envisaged that all Local Authorities will start developing and implementing UAW management structures in compliance with the Regulations. One section of the Regulations deals with requirements of annual water audits to be carried out by the Local Authorities. It is recommended that the information gathered for the audits be gathered for the be captured on a central data base for analysis and general dissemination to all interested parties.

ACKNOWLEDGEMENTS

The research in this report emanates from a project funded by the Water Research Commission entitled: "The Development of Procedures for the Control of Unaccounted-for Water in Water Distribution Systems and for the Reduction of Water Loss".

The Steering Committee over the term of the project consisted of the following persons:

Mr HC Chapman	:	Water Research Commission	(Chairperson)
Mr PW Weideman	:	Water Research Commission	(Committee Secretary)
Mr FP Marais	:	Water Research Commission	(Committee Secretary)
Mr AC Fritz	:	Water Research Commission	(Committee Secretary)
Mr DS van der Merwe	:	Water Research Commission	
Mr NA Macleod	:	Durban Corporation	
Mr GFP Keay	:	Johannesburg City Council	
Mr JP Maré	:	Kempton Park City Council	
Mr JD van Niekerk	:	Rand Water	
Mr GJ Malan	:	Development Bank of Southern Africa	
Mr CB Cubey	:	De Leuw Cather	
Mr DW Broadhurst	:	De Leuw Cather	

The authors express their sincere gratitude to the Water Research Commission for having funded the project and to the members of the Steering Committee for their contribution. Furthermore, the authors acknowledge with thanks the following:

Johannesburg City Council : Messrs PS Coetzee and D McConville for all the information regarding meter testing and pressure zoning.

Durban Corporation : Messrs IG Govender and P Boodhoo for their assistance with the in-situ domestic meter testing in Reservoir Hills, Durban and other general information regarding step testing, minimum night flows, etc.

Kempton Park City Council : Messrs G Rens, R Vermuelen and K Folscher for their assistance with the in-situ domestic meter testing in Rhodesfield and the information regarding the in-situ testing of large consumer meters in Kempton Park.

Pinelands Municipality : Messrs I Weston and I Seawyer for their assistance with the in-situ domestic meter testing and other general information regarding leak detection methods.

All respondents to the questionnaires.

Messrs EJ Hall and DJ Behrmann, formerly of De Leuw Cather, for the Project's inception and initial work.

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THE DEVELOPMENT OF PROCEDURES FOR THE CONTROL OF UNACCOUNTED-FOR WATER IN WATER DISTRIBUTION SYSTEMS AND FOR THE REDUCTION OF WATER LOSS

1. Introduction

In 1989 Mr HC Chapman of the Water Research Commission (WRC) attended the biennial conference of the International Water Supply Association (IWSA) in Copenhagen as the South African national rapporteur on unaccounted-for water (UAW). In his report entitled "Unaccounted-for Water and the Economics of Leak Detection"[25] Lai Cheng Cheong presented the following UAW figures of countries that had responded to his questionnaire:

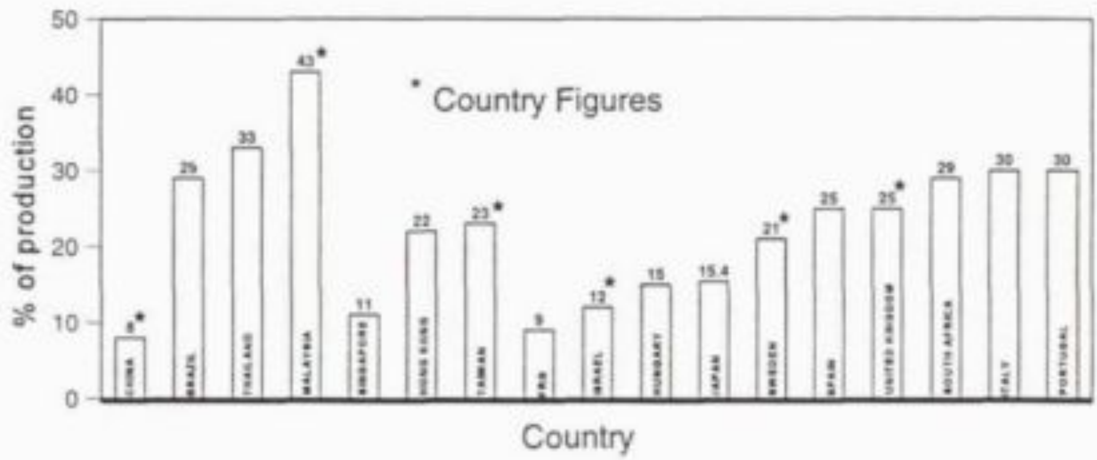

Figure 1 : Unaccounted-for Water as % of Production[25]

The figure of 29% for South Africa was obtained from a two year study carried out by the WRC and the Johannesburg City Council in the mid 1980's on an area covering 14% of the total municipal area of Johannesburg.

In 1991 it was estimated that the UAW in South Africa amounted to 20% of the total urban and industrial demand or 800 Gℓ/a.

From the papers presented by the various rapporteurs to the Conference, it became evident that South Africa was lagging behind world trends in UAW control. Most Local Authorities in South Africa employ passive rather than pre-emptive leakage control measures, i.e. only reacting to reports of leaks and bursts and consumer complaints regarding metered consumption. Furthermore, because of the relatively cheap cost of water, most Local Authorities compensate for revenue losses by increasing tariffs rather than implementing procedures for the control and reduction of all components of UAW.

By international definition, South Africa is classified as a water-stressed country approaching conditions of water scarcity. South Africa has a mean annual precipitation of 483mm as compared with a world average of 860mm. Clearly, through the increasing demands resulting from population growth, industrial development and agricultural needs, water is becoming an increasingly scarcer commodity.

The urgent implementation of comprehensive management procedures on a national basis is essential to safeguard the availability of this strategic resource in the interest of future generations of South Africans. Furthermore, international experience has shown that each new water source costs four times as much as its predecessor to develop. From an economic point of view it is therefore essential that all existing water sources are utilised to their utmost efficiency, thereby reducing or delaying the need to develop new sources.

2. The Research Project

In October 1991 DLC submitted a research proposal to the WRC entitled "The Development of Procedures for the Control of Unaccounted-for Water in Water Distribution Systems and for the Reduction in Water Loss". The specific objectives of the research were as follows:

a) To establish the status quo of Unaccounted-for Water (UAW) measurement and its quantification by water distribution authorities in the Republic.

b) To determine the approach and means currently employed in practice to quantify UAW and identify its components.

c) To develop a measure for the quantification of UAW which will be absolute so that it could be used for direct comparison of systems performance.

d) To develop procedures for the identification, and quantification where appropriate, and control of the contributing components of UAW.

e) To develop procedures to facilitate the evaluation of the benefit/cost of the control procedures.

f) To determine the mechanisms and causes of leak formation and to investigate and propose methods for the prevention or reduction of leaks.

On 28 February 1992 a Memorandum of Agreement between the WRC and DLC was signed for the implementation of the above research project. Subsequent to the inception of the Project, Mr Chapman pointed out that item (f) above was being addressed by a separate WRC project undertaken by the CSIR (Mattek) and the Water and Gas Department of the Johannesburg City Council. After discussion by the Steering Committee it was agreed that item (f) above should be replaced with the following:

f) To compile a comprehensive UAW manual for use by water distribution authorities.

3. Structure of the Research Project

To achieve the aims described in item 2 above the Project was divided into the following areas of work:

3.1 Literature Search

A literature search on a national and international basis was conducted of technical libraries, learned societies, water authorities and associations and other interested parties. By far the most comprehensive research done in the management of water leakage is that of the Water Research

Centre (WRc) in the United Kingdom. The research produced a series of reports entitled "Managing Leakage" published in October 1994. This publication was extensively drawn on in the preparation of the section on leakage control of the UAW Manual.

The other publications listed in the reference list also gave invaluable information regarding other aspects of UAW and were used, in conjunction with the research carried out under this project, to prepare the UAW Manual.

3.2 Survey of Local Authorities

A questionnaire was sent to a large number of Local Authorities in October 1992 in an effort to determine the status quo of UAW measurement and control in South Africa. The results and analysis of information gathered through these questionnaires are discussed in Section 6.

3.3 In-situ Meter Testing

Four Local Authorities, viz. Johannesburg, Kempton Park, Durban and Pinelands in the Cape, were selected to provide sites for the in-situ testing of domestic meters. Information regarding the in-situ meter testing of large consumers was obtained from Kempton Park. The results of these tests are discussed in Section 7.

3.4 Compilation of the UAW Manual

The information and results gathered from the above research was used to compile a UAW Manual for use by Local Authorities. The Manual deals with all aspects of UAW, giving guidance and recommendations on the formulation and implementation of systems for the effective control of UAW.

In November 1995 the South African Bureau of Standards (SABS) convened an Exploratory Committee, under project PRJ 801/54826, to prepare a Code of Practice for the Management of Potable Water Distribution Systems (CoP). It became evident that the UAW Manual and the CoP, although complementary to each other, would result in a substantial amount of duplication if published as separate documents. Furthermore, there existed the possibility of confusion arising from different terminology and definitions contained in the documents. For these reasons the CoP Committee suggested to the WRC that the UAW Manual and the CoP be combined into a single comprehensive document covering all aspects of water management. The WRC accepted this suggestion.

The UAW Manual, in the form that it was handed to the CoP Committee, is published separately under the title "Unaccounted-for Water : Guidelines for the Formulation of a Policy and Implementation of Practical Methods for the Control Thereof", WRC Report No 489/2/97.

4. Definition and Units of UAW

4.1 Definition of UAW

UAW is defined in various ways in different countries of the world. The following are a few examples:

a) Germany : "UAW is the difference between the quantity of water entering a system and the sum of water billed, including the water which is measured but for some reason not paid for".

b) Hong Kong : "UAW is the unrecorded consumption represented by the total raw water input into a system less the recorded consumption in domestic, commercial and industrial supplies to consumers as measured by consumer meters, and other known quantities of free supplies and system losses such as wash water in treatment works".

c) Malaysia and Phillippines prefer the term "non-revenue water" (NRW) to UAW.

d) Japan and Brazil prefer the term "effectively used water".

For the purpose of this Project, UAW is defined as:

"The difference between the measured volume of potable water having entered a distribution system and the measured volume of water having left the distribution system".

The measured volume of water leaving the system specifically excludes all estimates of unmetered water abstracted from the system for items such as pipe bursts and flushing, fire fighting, theft, reservoir leaks and overflows, meter stoppages, unmetered connections, etc. The measured volume of water leaving the system is limited to the aggregate of consumptions registered by metered consumer connections whether the consumer pays for the consumption or not. Typical consumptions which are not charged for include irrigation of Municipal parks and sports fields, flushing of reservoirs during maintenance, fire fighting, etc.

The reason for excluding estimates of water abstraction from the UAW equation is to eliminate the possibility of these figures being manipulated to give a lower UAW quantity. Diagrammatically the definition can be represented as shown in Figure 2.

Figure 2 : Definition of UAW

In terms of this definition, leaks downstream of meters measuring the abstraction of water from a distribution system do not affect the overall UAW value. Loss of water through these leaks, however, form an important part of leakage control and overall water conservation management. Factors such as meter inaccuracies, meter errors, etc., will influence the accuracy of this expression.

4.2 Units of UAW

Internationally, the most popular expression of UAW is as a percentage of the total measured volume entering the distribution system or as a percentage of the total water production. Although this unit is considered simplistic and even meaningless by some, it is nevertheless a popular expression that is readily understood and easily used for comparative purposes. For the expression to be more meaningful it should not be quoted in isolation but rather in conjunction with the actual volume of the UAW.

5. Components of UAW

5.1 General

The numerous components of UAW can, for the sake of convenience, be grouped as follows:

a) Leakage from the reticulation system.
b) Flushing of mains.
c) Reservoir leaks, overflows and flushing.
d) Fire fighting usage when not metered.
e) Meter inaccuracies.
f) Unmetered connections.
g) Theft and unauthorised usage.
h) Meter reading, data capture and processing errors.

These components can be divided into two groupings, viz.:

i) those components attributable to administrative errors; and
ii) those components attributable to the physical loss of water from a distribution system and discrepancies in measurements resulting from meter inaccuracies.

5.2 UAW Components Attributable to Administrative Errors

These components include the following:

a) Errors in meter reading whether accidental or deliberate.

b) Errors in transferring meter reading data to the accounting system.

c) Errors in the consumer data base.

d) Delays and errors in invoicing consumers.

e) Delays and errors in registering new consumers.

f) Bad debts.

The above components result in loss of revenue recorded by the Treasury Department of the Local Authority and not necessarily in the unmeasured abstraction of water from the distribution system. Accidental errors in the reading of meters and transferring meter reading data are generally corrected with subsequent meter readings. Deliberate errors in the reading of meters, especially if done in collusion with the consumer, constitutes theft.

Traditionally, the Treasury Department of a Local Authority is responsible for the reading of consumer meters, invoicing the consumers and the collection of revenue while the Water Department is responsible for the reading of bulk meters and the maintenance of the distribution system. This split of responsibility, specifically the reading of meters, leads to many administrative inaccuracies. Furthermore, the Treasury Department usually structures the consumer data base along township boundaries rather than reservoir or district boundaries. This makes it difficult to carry out a water audit of bulk meters versus consumer meters.

Inaccuracies of domestic water meters generally form a small portion of the total UAW while inaccuracies of large consumer and bulk meters can form a significant portion of UAW. The loss of revenue resulting from these components can be significant, however, and should be addressed by the implementation of strict administrative procedures by the Local Authority.

A practical and very effective method of reducing meter reading and data capture errors is through the use of hand held electronic terminals (HHT). DLC conducted a study on behalf of the Johannesburg City Council in 1992 entitled "Pilot Project to Evaluate Electronic Meter Reading Systems"[7]. The study found that time savings of 15% in meter reading, 40% in supervision and 50% in data capture could be achieved through the use of HHT. The occurrence of meter reading errors was dramatically reduced while errors in transferring readings from the HHT to the consumer data base were virtually eliminated. Local Authorities, such as the Durban Corporation and the Johannesburg City Council, who have introduced HHTs report dramatic improvements in the efficiency of meter reading and data processing.

5.3 UAW Components Attributable to Physical Losses

These components make up almost the entire volume of UAW and include the following in rough order of magnitude:

5.3.1 Leakage from the distribution system

Leakage from the distribution system can be subdivided into three groups, viz:

a) Visible leaks such as pipe bursts and breakages, leaks at valve flanges, hydrants and pipe fittings, etc.;

b) Invisible leaks where water leaking from the system has found its way into underground fissures or entered other services such as sewers, stormwater pipes, cable ducts, etc.; and

c) Leaks downstream of the consumer meter. These leaks can be either visible or invisible. They do not influence the UAW figure as they have been recorded on the consumer meter. The volume of water wasted through these leaks, especially in former black townships, can be extremely high, however.

5.3.2 Meter inaccuracies

Meter inaccuracies can be subdivided into the following categories:

a) Inherent meter errors resulting in meters either over-reading or under-reading the actual volume of water passing through them;

b) Meter malfunctions such as breakages or blockages which result in under-reading or zero reading; and

c) Incorrect meter sizing which results in the actual flow being outside the accurate flow range of the meter. This situation occurs mainly with large consumers and generally the meters are over-sized for the actual demand resulting in under-reading of actual consumption.

   The installation of meters too small for the actual consumption results in rapid deterioration of meter accuracy and even the total destruction of the moving mechanisms as a result of the excessive water velocities passing through the meters.

5.3.3 Unmetered connections

Unmetered connections can be divided into two categories, viz:

a) Authorised connections which are consumer connections installed by the Local Authority. These connections include irrigation points for Municipal parks and sports fields, standpipes in informal settlements, etc; and

b) Unauthorised connections which are connections installed by consumers without the permission and/or knowledge of the Local Authority. These connections occur mainly in informal settlements and areas of land invasion.

5.3.4 Flushing of mains

Flushing of mains occur on initial filling of a reticulation system and when repair work or pipe scouring operations are carried out in a system. The purpose of flushing the mains is to disinfect and remove any debris from the system at scour valves, hydrants or other control points.

5.3.5 Fire fighting

Fire hydrants and hose reels are very often unmetered so that any abstraction of water through these points, for any purpose, is not measured.

5.3.6 Reservoir leaks, overflows and flushing

Leaks in reservoirs are a common occurrence and are generally expensive to repair. Often, reservoir leaks are not visible and are only detected through routine drop tests investigations or underwater surveys. Generally, reservoir leaks are only repaired when the amount of water leaking from a reservoir makes it economically justifiable to implement extensive reservoir repairs.

Reservoir overflows result from the failure of inlet control mechanisms. The most common type of overflow system is bellmouth arrangement constructed inside the reservoir. The overflow pipe is usually connected to the scour pipe which in turn is lead to some natural water course or stormwater pipe. This often results in overflows remaining undetected for long periods of time especially in the case of intermittent overflows occurring during hours of low demand.

Flushing of reservoirs occurs when the reservoir undergoes routine maintenance or unscheduled emptying for repairs. The water used for flushing is scoured to waste.

5.3.7 Theft

The most common forms of theft are the by-passing of or tampering with consumer meters and the use of fire hose reels for purposes other than fire fighting. Very often the culprit is unaware of the illegality of using fire hose reels for purposes other than fire fighting, believing that the hose reels are metered through his domestic water connection.

A less common form of theft is the collusion between the consumer and meter reader whereby the meter reader falsifies consumption figures.

The occurrence of unauthorised connections as described in 5.3.3.(b) is currently a sensitive socio-political issue and is therefore not classified as theft but rather as unauthorised usage.

6. The UAW Questionnaire

6.1 General

A questionnaire, aimed at establishing the status quo of UAW measurement, its quantification and control, was sent to 141 Local Authorities in South Africa in October 1992. A total of 55 questionnaires were returned of which 31 were found suitable for analytical purposes. A copy of the questionnaire, together with tabulated results, are given in Appendix A.

The most common reasons for the omission of 24 of the returned questionnaires were incomplete data and/or the stated measured volume of water entering the system being less than the measured volume of water leaving the system.

6.2 Statistical Analysis of Results

The data collected from the questionnaire were statistically analysed to determine the existence of meaningful correlation between them. For the purpose of this exercise the following definitions were used:

a) The absolute UAW is the difference between the average daily volume of water supplied to the system and average daily volume of water sold, i.e.

$$UAW_{abs}\ (M\ell/d) = V_{supplied}\ (M\ell/d) - V_{sold}\ (M\ell/d)$$

b) $UAW_{\ell/m/d}$ = UAW in litres per metre of main per day

$$= \frac{UAW_{abs}\ (M\ell/d) \times 10^6}{\text{Length of mains (m)}}$$

c) $UAW_{\ell/c/d}$ = UAW in litres per connection per day

$$= \frac{UAW_{abs}\ (M\ell/d) \times 10^6}{\text{Number of connections}}$$

d) $$UAW_{\%} = \frac{UAW_{abs}\ (M\ell/d) \times 100}{V_{supplied}\ (M\ell/d)}$$

Based on the above definitions the following correlation table was produced:

	Length of Mains (km)	Total No. of Connections	Ave. Water Supplied (Mℓ/d)	UAW Absolute	UAW (ℓ/m/d)	UAW (ℓ/c/d)	UAW (%)
Length of Mains (km)	1,0000	0,9868	0,9878	0,9782	0,5252	0,2875	0,0678
Total No. of Connections	0,9868	1,0000	0,9868	0,9664	0,5572	0,9868	-0,0018
Ave.Water Supplied (Mℓ/d)	0,9878	0,9868	1,0000	0,9896	0,6116	0,3026	0,0534
UAW Absolute	0,9782	0,9664	0,9896	1,0000	0,6060	0,3565	0,1477
UAW (ℓ/m/d)	0,5252	0,5572	0,6116	0,6060	1,0000	0,4822	0,1926
UAW (ℓ/c/d)	0,2875	0,2049	0,3026	0,3565	0,4822	1,0000	0,4307
UAW (%)	0,0678	-0,0018	0,0534	0,1477	0,1926	0,4307	1,0000

Table 1 : Correlation between System Parameters

As expected there is a good correlation between the first four parameters, i.e. length of main total number of connections, average daily water supplied and UAW_{abs}.

The remaining parameters, i.e. $UAW_{ℓ/m/d}$, $UAW_{ℓ/c/d}$ and $UAW_{\%}$ show no correlation between themselves or the other parameters. The non-correlation between the various UAW expressions is probably a result of the sample size and inconsistencies in the data retrieved from the questionnaires as described in Section 6.1.

The non-correlation between the UAW expressions and other system parameters tends to support the theory that UAW, other than UAW_{abs}, is not dependant on system size.

6.3 Average UAW Values

Based on simple statistical analysis of the 31 questionnaires the following average values were obtained:

Average $UAW_{(\%)}$ = 12,84%
Average $UAW_{(ℓ/m/d)}$ = 11,11 ℓ/m/d
Average $UAW_{(ℓ/c/d)}$ = 395,1 ℓ/c/d

7. In-situ Meter Testing

7.1 General

Abundant literature is available from meter manufactures and other sources regarding the accuracy of meters under test-bench conditions for both new and used meters. In-situ testing of domestic water meters were carried out in order to determine their accuracy under installed rather than test-bench conditions. Areas in Johannesburg, Kempton Park, Durban and Pinelands (Cape) were chosen for this investigation.

In-situ meter testing of large consumers was carried out by the Kempton Park City Council throughout its municipal area.

7.2 Procedure for Domestic Water Meter Testing

The test procedures used for the testing of domestic water meters were as follows:

a) A suitable area within the Local Authority's boundary was chosen at random and demarcated on a plan.

b) Field record sheets were prepared for the chosen area. Examples of the field record sheet used for the various areas are given in Appendix B.

c) Notice of the proposed meter tests, written on the Local Authority's letterhead, were distributed to the affected consumers in advance, explaining the purpose of the test and giving other pertinent details of the investigation. A typical example of the notice is given in Figure 3.

> Local Authority
> logo and address
>
> TO THE RESIDENT
>
> WATER METER TESTING IN *(name of suburb)*
>
> During the month of *(state month)*, this department will be carrying out flow tests on your water meter. The results form an important part of the research conducted by this Department into water meter performance. We will be requiring access to your garden tap. Every effort will be made to minimise the disruption of your water supply. This will be limited to approximately one hour during the hours of *(state hours)* on the day in question. The water used will amount to less than R1,00 (One Rand).
>
> Your co-operation will be greatly appreciated.
>
> DIRECTOR

Figure : 3 Typical Notice of Meter Test

d) The day before the test, the test-rig was checked to ensure that it was in proper working order.

e) On the day of the test one of the team members went ahead of the test crew and checked that the meters to be tested were working and had no leaks. He also advised residents that the meter test would be carried out shortly.

f) The test crew requested the resident not to use any water for the duration of the test. Before setting up the test-rig the crew ascertained that there were no leaks on the property by checking that the meter was completely stopped. If any leaks were found, no test was carried out at that site.

g) Three tests each for slow, medium and fast flows were carried out and recorded on the data sheets.

h) Once the test was completed the resident was thanked for his co-operation and the test crew moved onto the next site.

i) The test sheets were transferred to a spreadsheet and analysed.

7.3 Test-Rigs for Domestic Water Meters

Two types of test-rigs were used as shown schematically in Figure 5 and Figure 6 below. The test-rig shown in Figure 5 was used in Johannesburg and Pinelands and that shown in Figure 6 was used in Kempton Park and Durban.

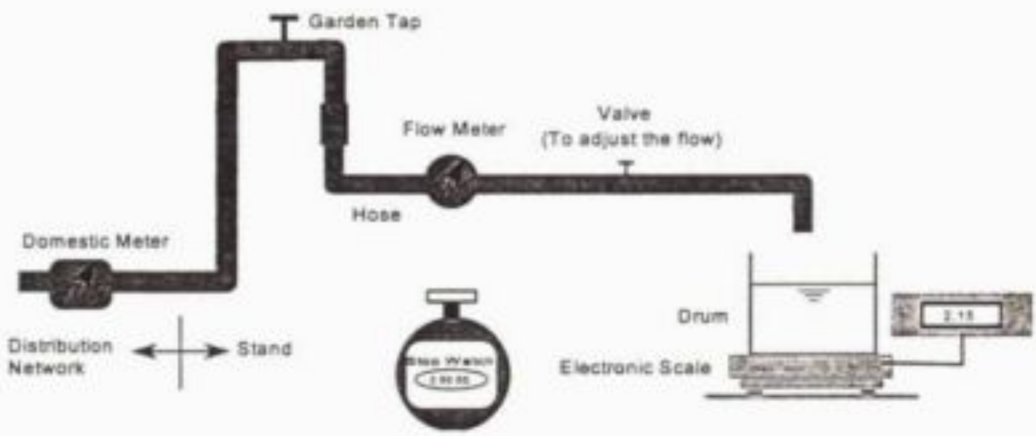

Figure 5 : Schematic of Test-Rig used in Johannesburg and Pinelands

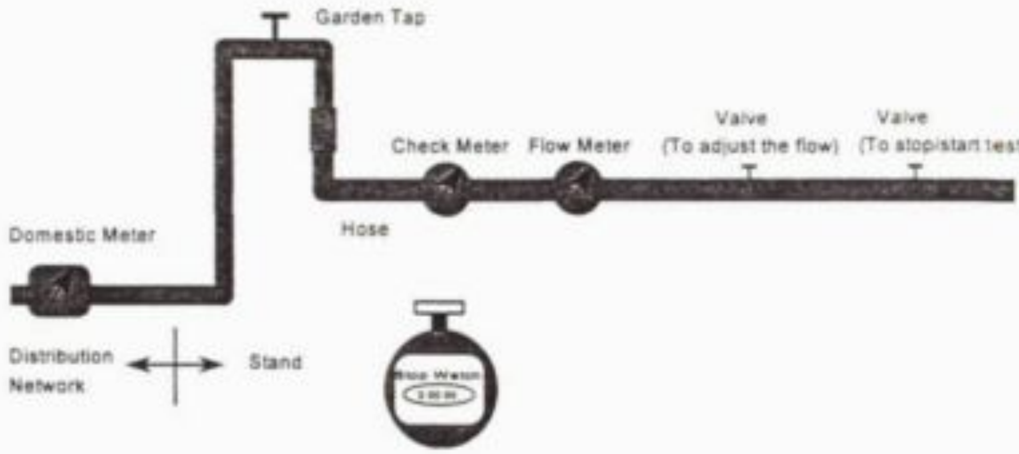

Figure 6 : Schematic of Test-Rig used in Kempton Park and Durban

The latter test-rig was found to be more efficient. This rig does not limit the volume of water used for each test. Furthermore, the scale of the former test rig was sensitive to wind disturbances. A drawback of the latter rig is that the check meter must be of a very high quality capable of accurately measuring flows as low as 1ℓ/min.

7.4 Problems Encountered with Meter Readers

Meter Readers from the Local Authorities were used to assist with the in-situ testing of domestic meters. It was found that being accustomed to reading whole numbers only, the meter readers had difficulty in reading the decimal graduations accurately. This resulted in a number of test results, especially for the low flow tests, having to be discarded because of spurious results.

7.5 Analysis of Test Results

Meter errors were calculated using the following formula:

$$Error_{\%} = \frac{V_{read} - V_{measured} \times 100}{V_{measured}}$$

where V_{read} = volume of water read on the test meter

$V_{measured}$ = volume of water measured by the test-rig

In the above equation a positive error indicates that the meter is over-reading, i.e. less water has passed through the meter than is indicated by it. A negative error indicates that the meter is under-reading, i.e. more water has passed through the meter than indicated by it.

The results of the tests for each area are tabulated in Appendix B. From these results the following general observations can be made:

a) Meter accuracy deteriorates with time or volume of water passing through the meter. The accurate reading life span of the meters could not be determined from the tests carried out. In some instances, two-year old meters were found to be inaccurate while 20-year old meters were still recording accurately.

b) Meter inaccuracies were both positive and negative. This results in inaccuracies cancelling out each other so that the UAW component attributable to meter inaccuracy is difficult to determine with certainty.

c) Percentage errors at low flows are higher than at high or full bore flows.

d) Positive displacement meters tend to under-read at high flows and over-read at other flows. Multi-jet meters tend to over-read at all flows.

7.6 Procedures for Meter Testing of Large Consumers

The in-situ meter testing of large consumers in Kempton Park was carried out by Council personnel. The procedures used were similar to those used for domestic water meters with the exception that test points were installed in the consumer connection prior to the test. This allowed the monitoring of the check meter for extended periods of time without causing any inconvenience to the consumer. The schematic of the test-rig used for this exercise is shown in Figure 7.

Two type of tests were carried out at each meter, viz:

7.6.1 Meter accuracy test

This test was carried out to determine the accuracy of the meter at low, medium and high flows. The principles used for this test were identical to those used for the domestic water meter tests.

7.6.2 Meter size and type test

This test was carried out to determine the correct size and type of meter for the individual consumer. Water to the consumers was diverted through a check meter and logged for a 24-hour period. The demand pattern thus recorded was analysed to ascertain the correct size and type of meter for the particular consumer.

The test results are tabulated in Appendix B.

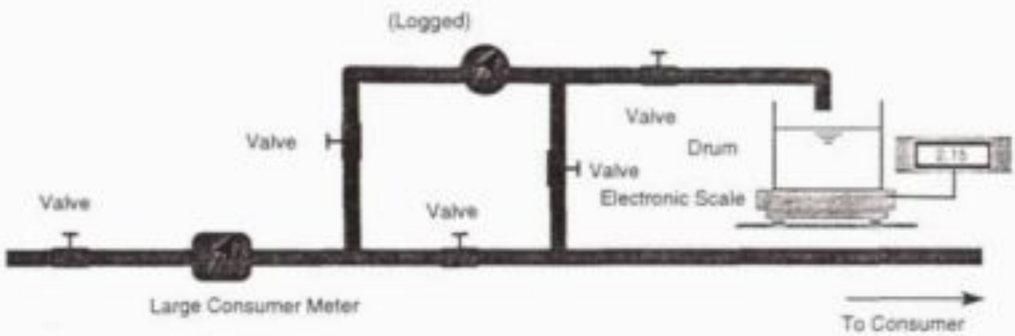

Figure 7 : Schematic of Test-Rig for Large Consumer Meter Tests

7.7 Conclusions

Based on the foregoing the following conclusions were made:

7.7.1 In-situ meter testing

The in-situ sample testing of consumer meters is an invaluable tool for assessing the performance of meters in different areas and various conditions of installation. However, this test should not be carried out once only but rather at several convenient time intervals so that a data base of meter performance can be established from this a meter replacement policy can be formulated. Of great importance is the in-situ testing of meters of large consumers, an area where considerable UAW and revenue loss can be eliminated.

Meter readers must be properly trained in reading the decimal graduations correctly prior to the in-situ test being carried out.

7.7.2 Responsibility for meter reading

The reading of consumer meters should become the responsibility of the Water Department and not the Treasury Department. The Water Department would then transfer all the relevant information from its meter data base to the Treasury Department for billing purposes.

This system has the added benefit that the Water Department data base would be structured along reservoir or supply zone boundaries, making water audits easier and more meaningful.

7.7.3 Hand held terminals

The use of hand held electronic terminals for meter reading purposes, rather than the book entry system, holds many advantages for the Local Authority.

8. The UAW Manual

As discussed in item 2(f), one of the objectives of this Project was "To compile a comprehensive UAW manual for use by water distribution authorities". With the decision of combining the UAW Manual with the CoP for the Management of Potable Water Distribution Systems, the UAW Manual was revised so that it conformed with the definitions, terminology and structure of the CoP. The UAW Manual, as handed to the CoP Committee, is published as WRC Report No 489/2/97. However, once the CoP is published, the UAW Manual will be superseded by it.

9. Discussions, Conclusions and Recommendations

9.1 Achievements of the Project

9.1.1. Objective 2 (a) of the Project

With regard to the Project objective described in item 2 (a), the research has determined that the status quo of UAW management in South Africa varies considerably from one Local Authority to another. In some instances, such as the Durban Corporation, Johannesburg City Council, Kempton Park City Council and Pinelands Municipality, there are comprehensive and active UAW management structures in place. This is largely due to senior management officials who are committed and dedicated to the principles of UAW management.

In other instances, especially the smaller Local Authorities, there is little or no attempt at UAW management. These Local Authorities generally use reactive means of leakage control and compensate for any loss of revenue by adjusting water tariffs on a regular basis.

Generally the status quo of UAW management and knowledge is alarmingly low for the water-stressed conditions prevailing in South Africa.

9.1.2 Objective 2(b) of the Project

With regard to the Project objective described in item 2(b), the research determined that the definition and method of quantification of UAW varied considerably from one local Authority to another. This, together with the lack of widespread information, has made it impossible to quantify UAW on a national basis. The situation has been further exacerbated by a culture of non-payment of services and the virtual collapse of Local Authority governance in some of the former black areas.

The rapid urbanisation experienced in South Africa since the late 1980s has resulted in a tremendous increase in the number of consumers within the Local Authorities' areas of jurisdiction. In most cases the Local Authorities have not had the resources to meter and monitor all new consumers. Furthermore, land invasions have resulted in the widespread practice of consumers installing connections without the authority and/or knowledge of the Local Authority.

From the replies to the questionnaires UAW_{abs} ranged from 3,57 Mℓ/d to 59,34 Mℓ/d and from 2,8% to 34,8% of the average daily volume of water supplied to the system. Estimates of national UAW given in various publications range from 12,8% to 40% of the total production of water which is slightly more conservative than the research indicates.

9.1.3 Objectives 2(c) to 2(f) of the Project

The Project objectives described in items 2 (c) to 2 (e) are all incorporated in item 2 (f), i.e. the compilation of a comprehensive UAW Manual which is included in Appendix C. With the incorporation of the UAW Manual into the CoP, these objectives have been met and surpassed.

9.2 Conclusions

Although the objectives of the Project have been achieved with the exception of determining the national status quo and quantity of UAW mainly due to the lack of comprehensive and compatible information, the compilation of the UAW Manual has further expanded on most of the Project objectives. It is envisaged that with the recent introduction of the National Water Supply Regulations and the imminent publication of the CoP incorporating the UAW Manual, all Local Authorities will start developing and implementing UAW management structures. The Regulations require that the Local Authorities carry out comprehensive annual water audits. The information gathered by these audits over a period of time will give an accurate indication of the national UAW situation.

9.3 Recommendations

The authors recommend that a standing committee be formed under the auspices of a statutory body such as the Department of Water Affairs and Forestry, WRC, WISA, or any other suitable body, with the purpose of collecting the data of the annual water audits from all Local Authorities and capturing this data on a central data base. The information could then be used to determine national norms of UAW which Local Authorities could use as a bench mark in assessing their performance in the management and control of UAW.

The authors recommend further that once the CoP, incorporating the UAW Manual, is published it should be presented at a series of nation-wide seminars to as many Local Authorities as possible.

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APPENDIX A
UAW QUESTIONNAIRE AND ANALYSIS

CONTENTS — PAGE

QUESTIONNAIRE : UAW AND WATER DISTRIBUTION SYSTEMS : 1992/1993

Authority title:

1.	Total length of distribution and trunk mains (excl leads)		km
2.	Operating budget		c/kl
3.	Number of connections	domestic other Total	No No No
4.	Average quantity of water supplied into system		Mℓ/d
5.	Average purchase price		c/kl
6.	Average total quantity of water sold	domestic other (own town) other towns Total	Mℓ/d Mℓ/d Mℓ/d Mℓ/d
7.	Average selling price	domestic other Total	c/kl c/kl c/kl
8.	Your estimate of unaccounted for water (UAW) expressed as a percentage of water purchased/produced		%

Please circle the appropriate answers for questions 9 to 16

9.	Are all consumers metered ?	Yes/No
10.	How do you determine ummetered consumption ?	Do not/Estimated
11.	Is your department responsible for meter reading ?	Yes/No
12.	Do you have a programme in place to test or replace meters ?	Yes/No
13.	Do you operate zone metering to measure water leak losses ?	Yes/No
14.	Do you have any system in place to control leakage losses ?	Yes/No
15.	Do you have a programme for the maintenance of fittings ?	Yes/No
16.	Would you like to be more involved in this project ?	Yes/No

Please comment briefly here if answers to 10, 12, 14, & 15 above are positive:

....

....

Any other comment or relevant information ? ....

....

Signed: .... Designation: ....

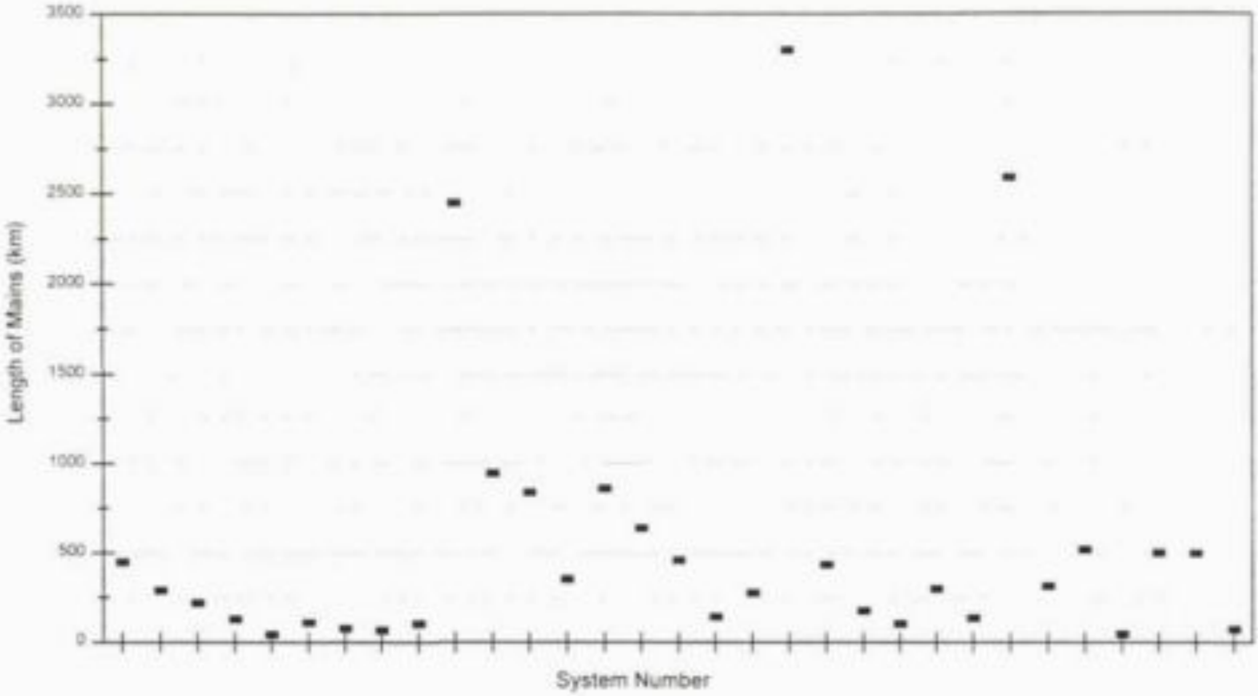
Name: .... Business Telephone: ....

Business Fax: ....

UAW QUESTIONAIRE RESPONDENTS: TABULATED DATA

System Number	PROVINCE	TOWN OR CITY	Length of mains	Number of connections			Average daily volume of water					UAW			
			km	Domestic	Other	Total	Supplied Ml/d	Sold-domestic Ml/d	Sold - other Ml/d	Sold other town Ml/d	Total sold Ml/d	Absolute Ml/d	%	[illegible]	[illegible]
1	Cape Province	BELVILLE	450	16500	1750	18250	42.50	40.30	0.00	0.00	40.30	2.20	5.18	4.89	120.55
2	Cape Province	GEORGE	290	9500	1000	10500	15.83	3.99	7.43	3.09	14.51	1.32	8.34	4.55	125.71
3	Cape Province	GOODWOOD	220	11400	2500	13900	16.00	10.00	4.70	0.00	14.70	1.30	8.13	5.91	93.53
4	Cape Province	KNYSNA	130	3757	345	4102	5.09	2.17	1.18	0.43	3.78	1.31	25.74	10.08	319.36
5	Cape Province	PAARL	43	11692	288	11980	30.57	12.73	14.47	2.61	29.81	0.76	2.49	17.67	63.44
6	Cape Province	PRIESKA	112	647	140	787	5.40	3.50	0.60	0.50	4.60	0.80	14.81	7.14	1 016.52
7	Cape Province	SIMON'S TOWN	80	1547	325	1872	4.90	2.40	2.30	0.00	4.70	0.20	4.08	2.50	106.84
8	Cape Province	SWELLENDAM	70	1579	169	1748	2.21	1.24	0.20	0.00	1.44	0.77	34.84	11.00	440.50
9	Cape Province	WELLINGTON	104	4796	327	5123	8.10				7.36	0.74	9.14	7.12	144.45
10	Natal	DURBAN	2453	127000	5000	132000	488.00	312.00	0.00	145.00	457.00	31.00	6.35	12.64	234.85
11	Natal	PORT NATAL-EBHODWE	945	20730	3152	23882	72.00	30.00	32.00	5.00	67.00	5.00	6.94	5.29	209.36
12	Natal	PIETERMARITZBURG	838			32804	69.88	24.60	32.04	0.00	56.64	13.24	18.95	15.80	403.61
13	Natal	RICHARDS BAY	354			4695	34.15	9.93	20.06	0.00	29.99	4.16	12.18	11.75	886.05
14	Free State	BLOEMFONTEIN	860	21506	3064	24570	105.00	85.00			85.00	20.00	19.05	23.26	814.00
15	Transvaal	BENONI	640	18000	4480	22480	46.48	35.10	3.65	2.70	41.45	5.03	10.82	7.86	223.75
16	Transvaal	BRAKPAN	460	11822	447	12269	48.00	35.00	3.00	3.00	41.00	7.00	14.58	15.22	570.54
17	Transvaal	BRITS	145	2200	400	2600	18.00		9.05	6.69	15.74	2.26	12.56	15.59	869.23
18	Transvaal	EDENVALE	279	7689	1029	8718	19.40	11.40	4.80	0.00	16.20	3.20	16.49	11.51	367.06
19	Transvaal	JOHANNESBURG	3300	104000	36000	140000	429.00	206.00	121.00	63.50	390.50	38.50	8.97	11.67	275.00
20	Transvaal	KLERKSDORP	438	13598	100	13698	39.22	27.51	3.45	6.73	37.69	1.53	3.90	3.49	111.70
21	Transvaal	NELSPRUIT	178	4809	396	5205	22.68	10.30	8.74	0.00	19.04	3.64	16.05	20.45	699.33
22	Transvaal	PHALABORWA	104	2800	0	2800	16.40				14.40	2.00	12.20	19.23	714.29
23	Transvaal	POTCHEFSTROOM	300	9606	878	10484	36.36	17.85	7.33	6.88	32.06	4.30	11.83	14.33	410.15
24	Transvaal	POTGIETERSRUS	138	2495	635	3130	5.40	2.25	2.46	0.00	4.71	0.69	12.78	5.00	220.45
25	Transvaal	PRETORIA	2591	80976	6861	87837	335.00	122.40	126.68	26.58	275.66	59.34	17.71	22.90	675.57
26	Transvaal	RUSTENBURG	315	11149	453	11602	42.00	28.60	10.10	0.00	38.70	3.30	7.86	10.48	284.43
27	Transvaal	SPRINGS	520	14600	1350	15950	47.36	15.60	28.58	0.00	44.18	3.18	6.71	6.12	199.37
28	Transvaal	THABAZIMBI	46	1027	196	1223	2.29	0.88	1.00	0.05	1.93	0.36	15.72	7.83	294.36
29	Transvaal	VANDERBIJLPARK	502	14946	717	15663	47.06	25.22	15.46	0.00	40.68	6.38	13.56	12.71	407.33
30	Transvaal	VERWOERDBURG	500			18000	35.60				32.00	3.60	10.11	7.20	200.00
31	Transvaal	ZEERUST	75	1045	221	1266	1.57	0.94	0.38	0.00	1.32	0.25	15.92	3.33	197.47

Scatter of Mains



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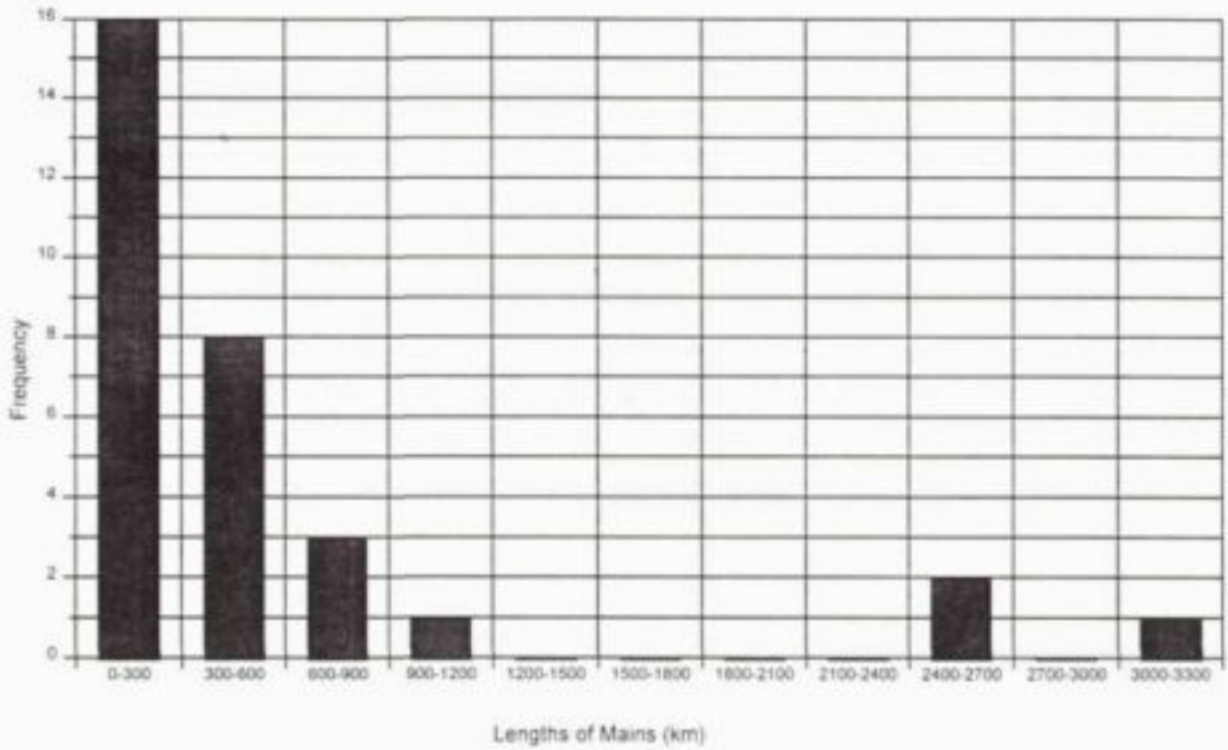

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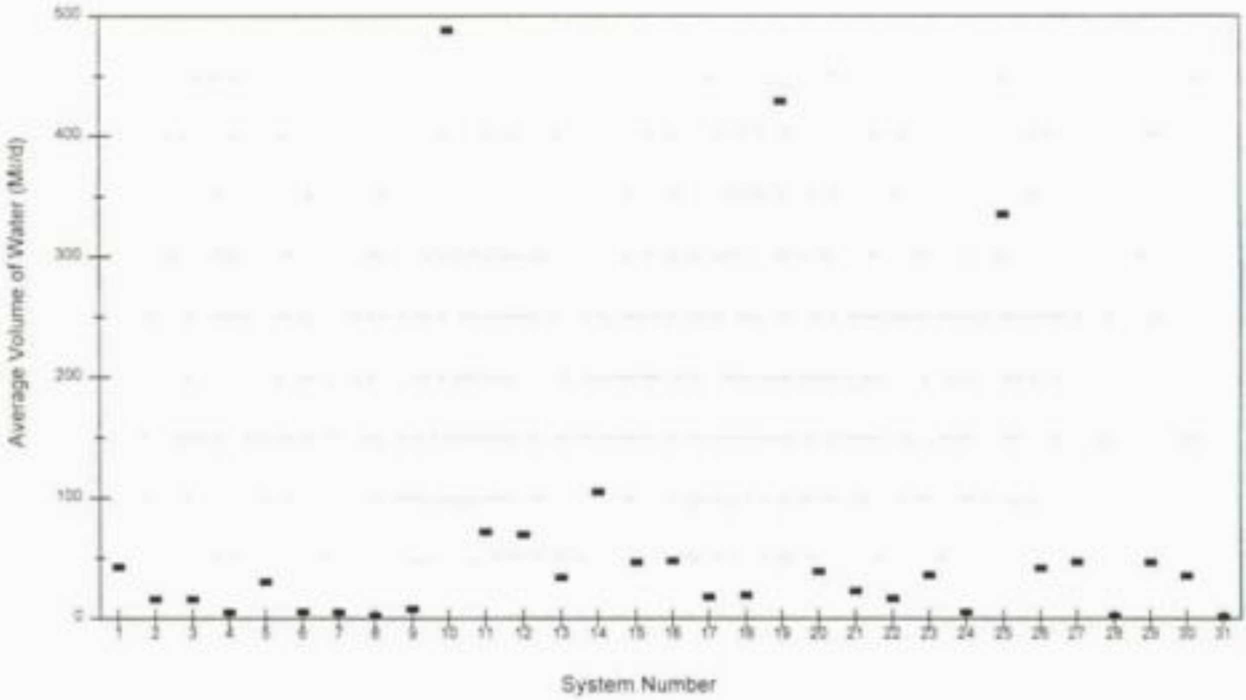

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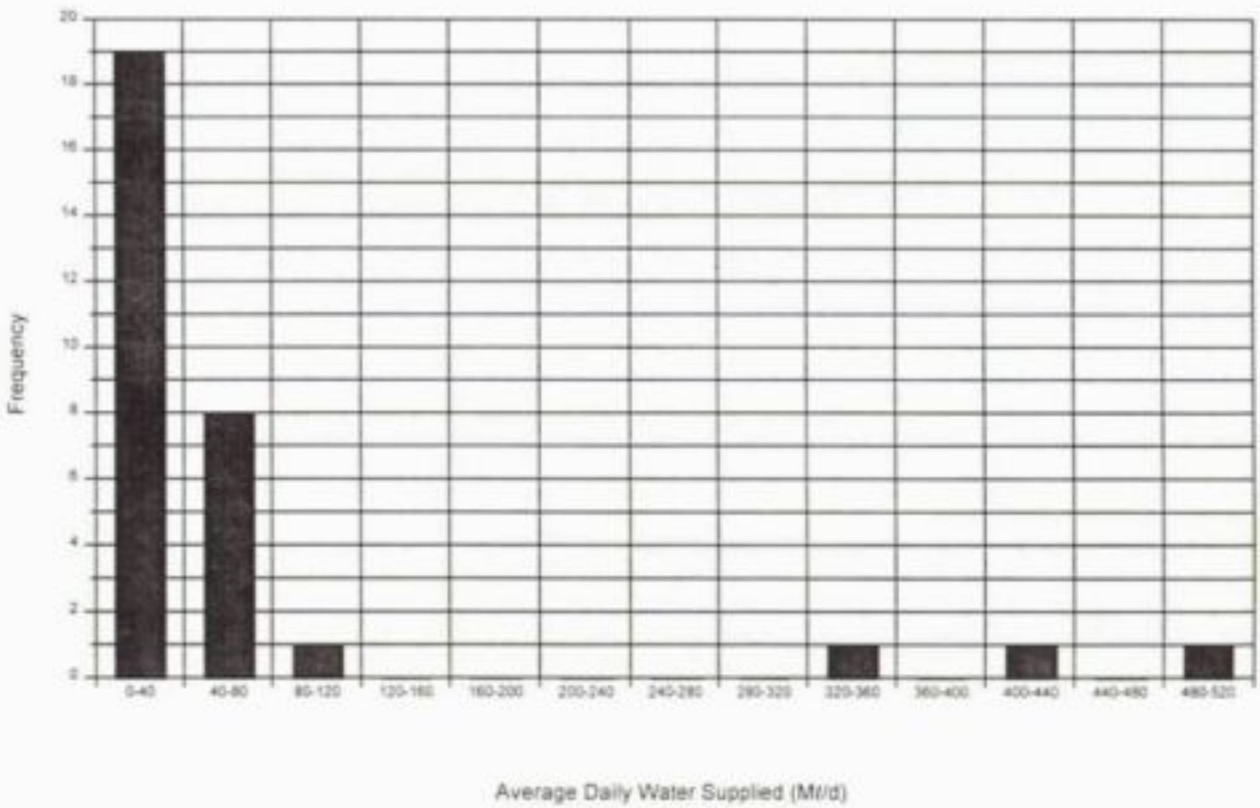

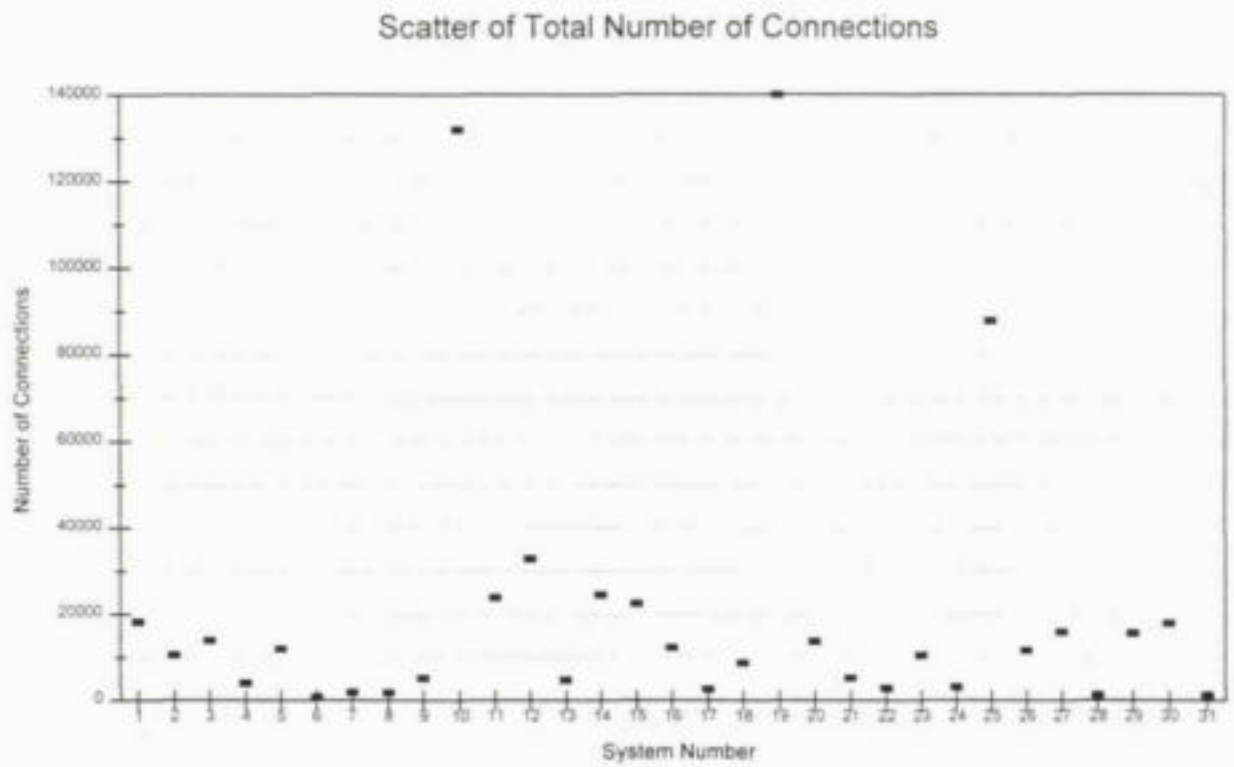
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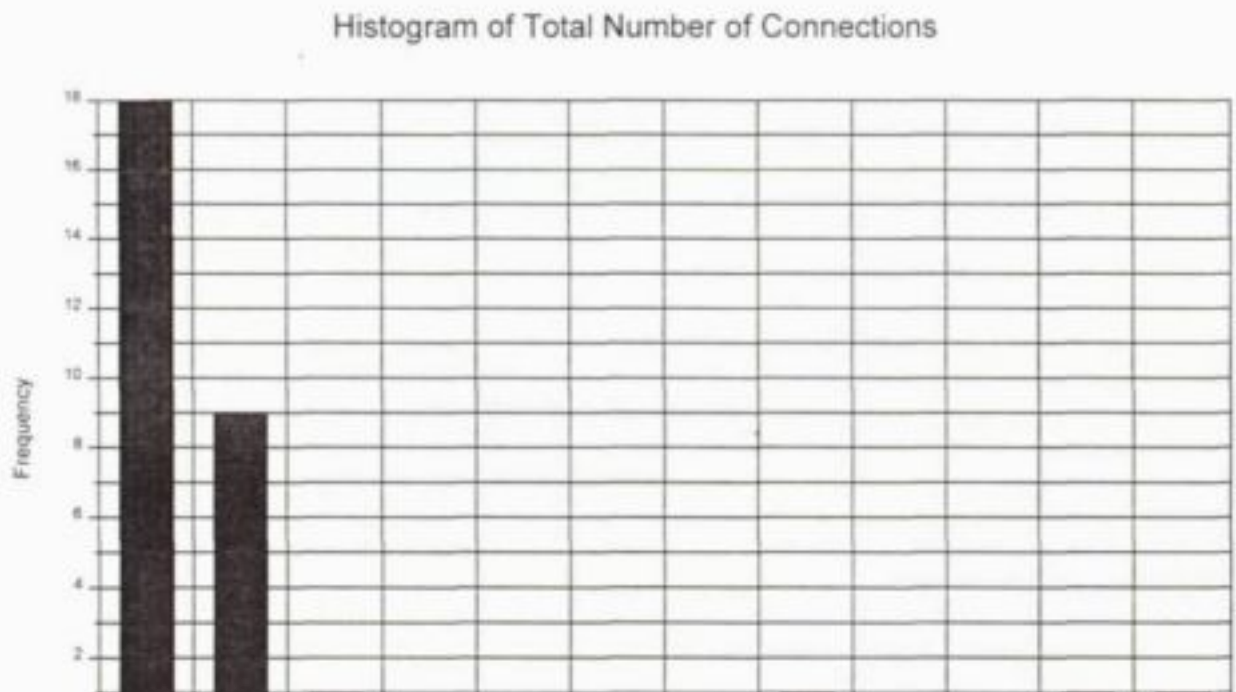
Number of Connections
System Number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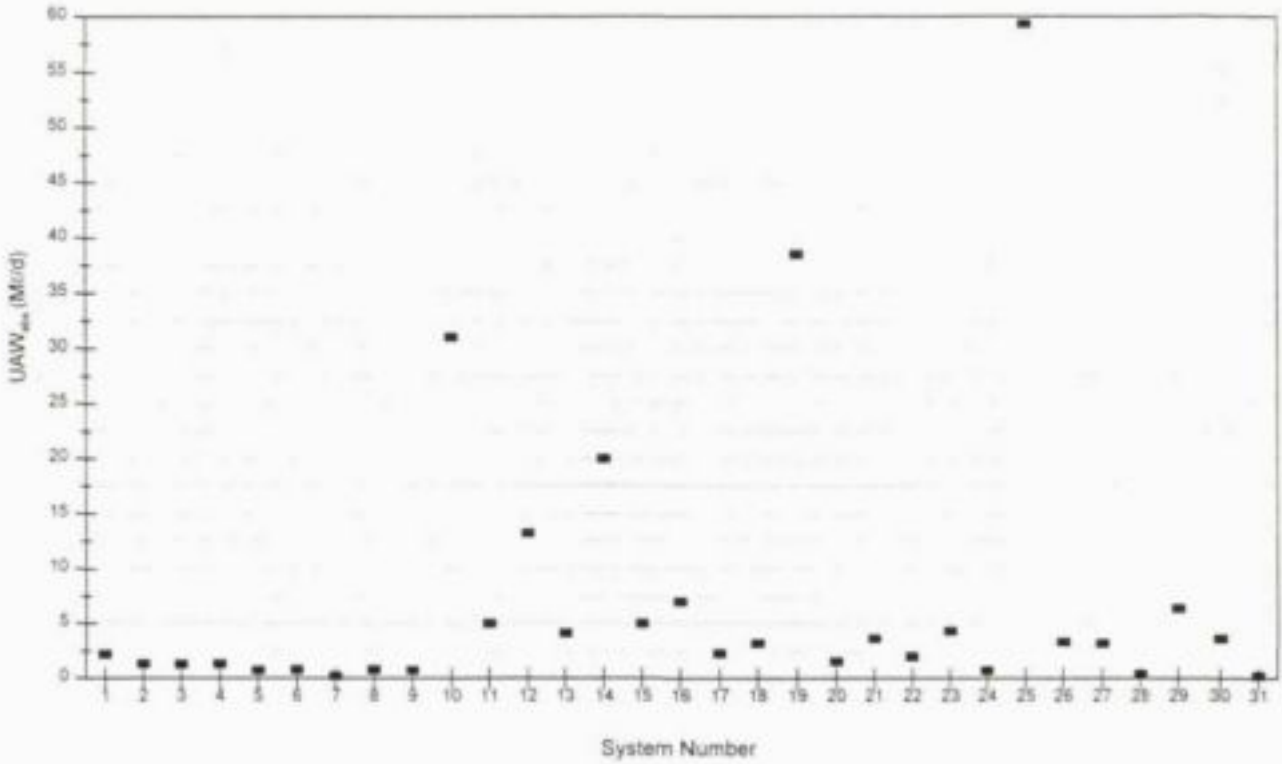
Frequency
Number of Connections

Scatter of UAW_{abs}



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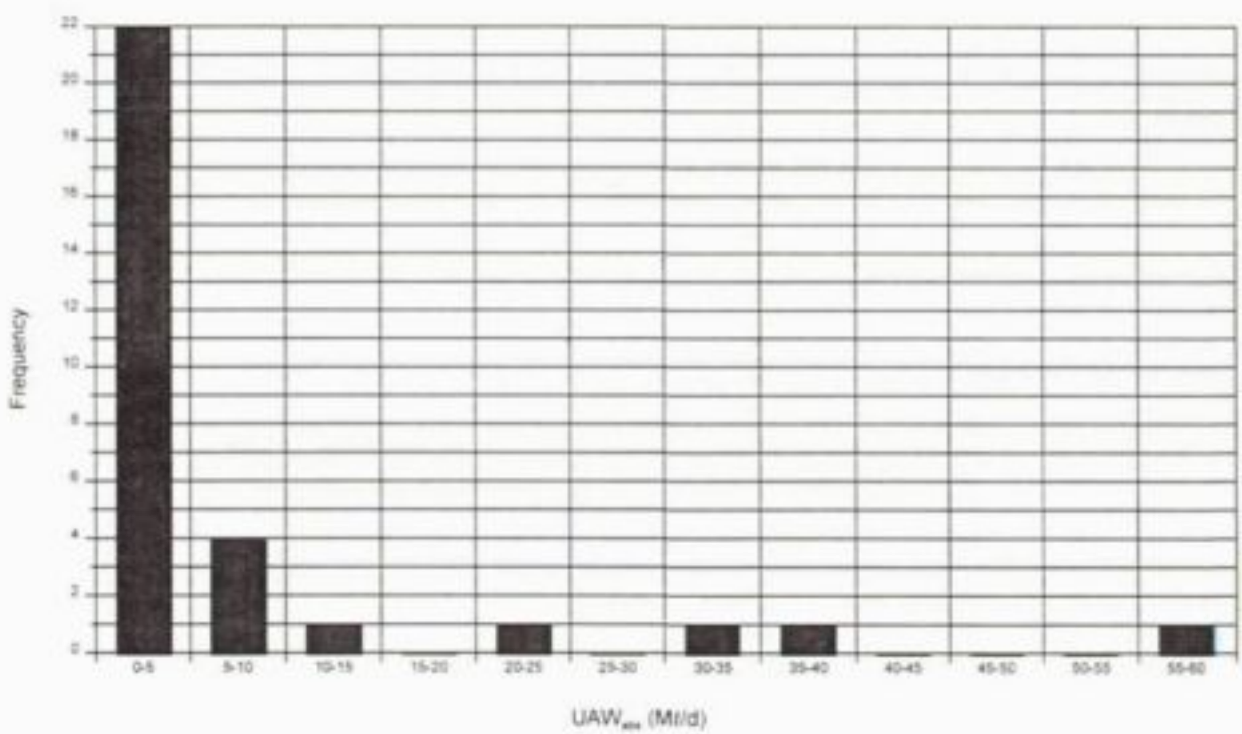
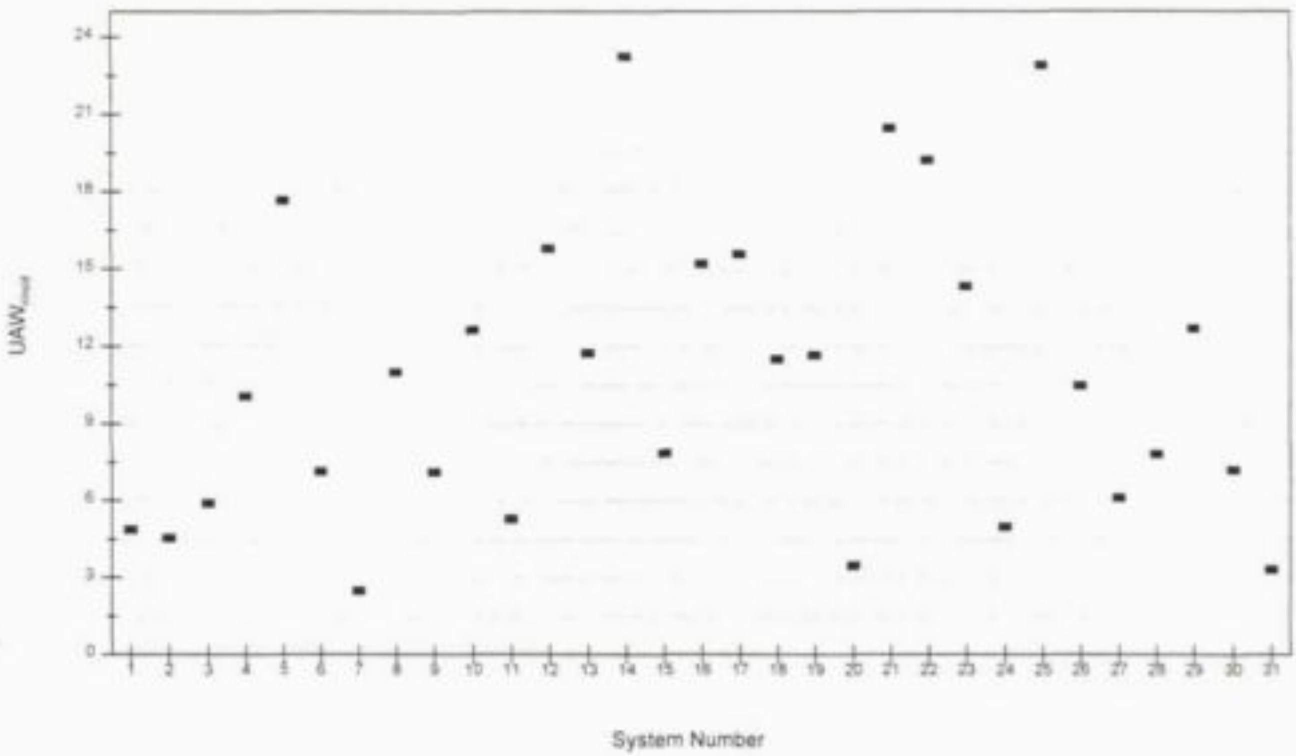


Scatter of $UAW_{l/m/d}$



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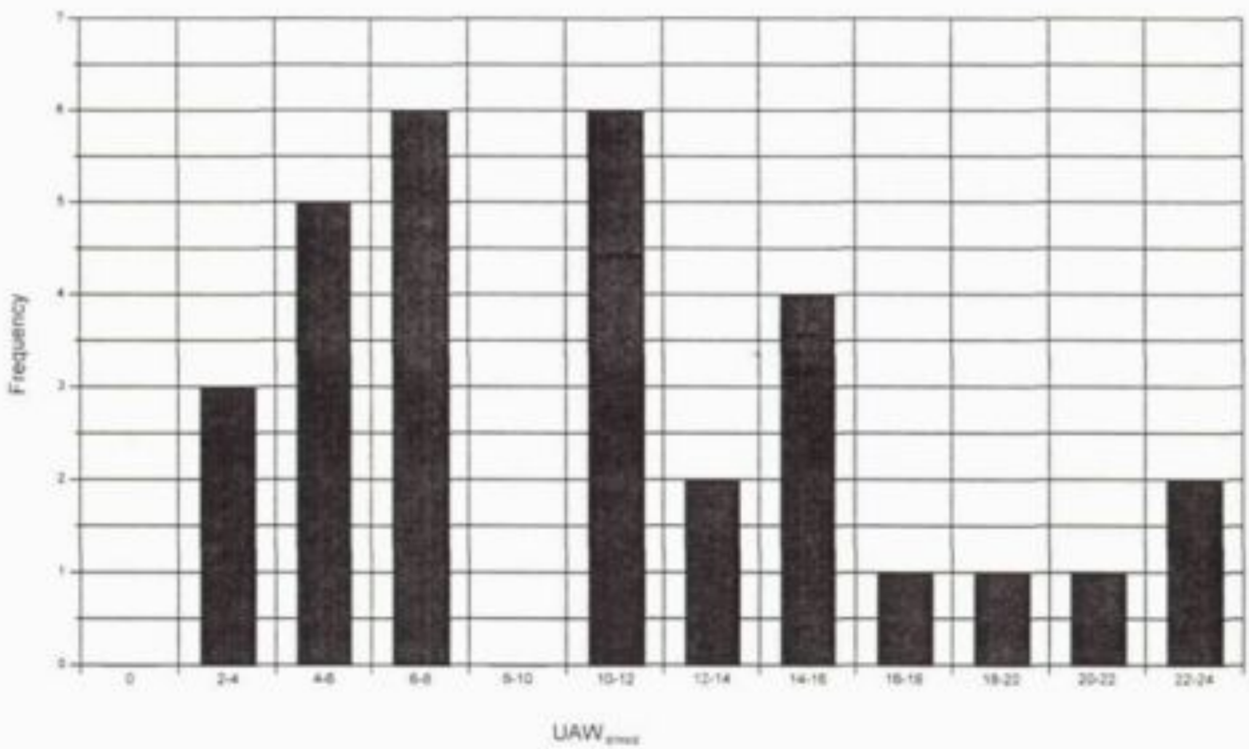

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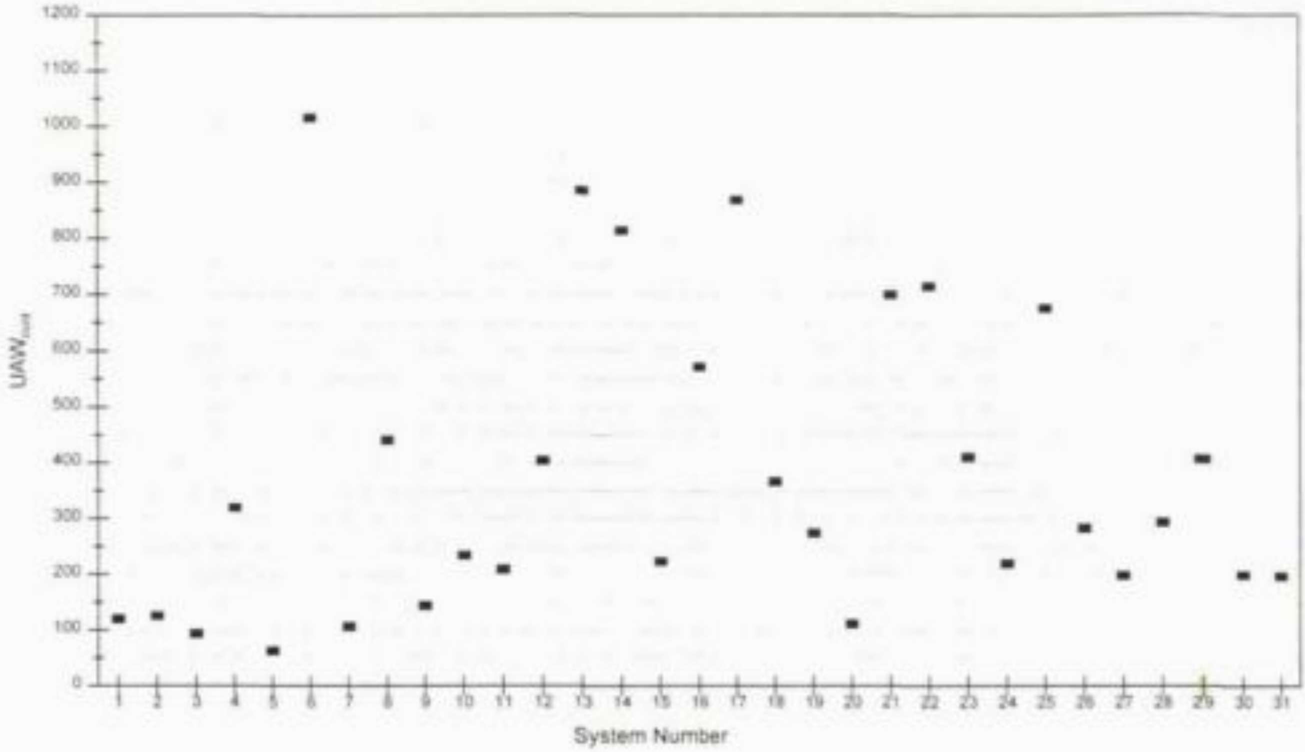

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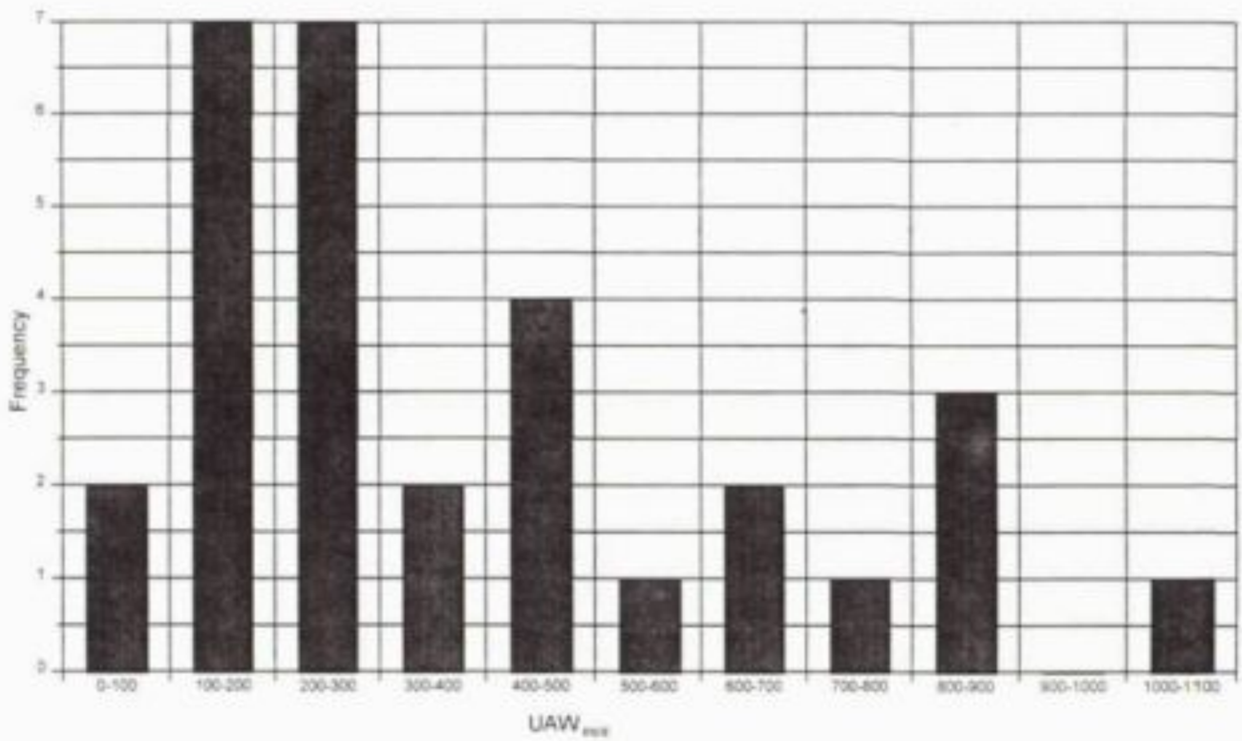
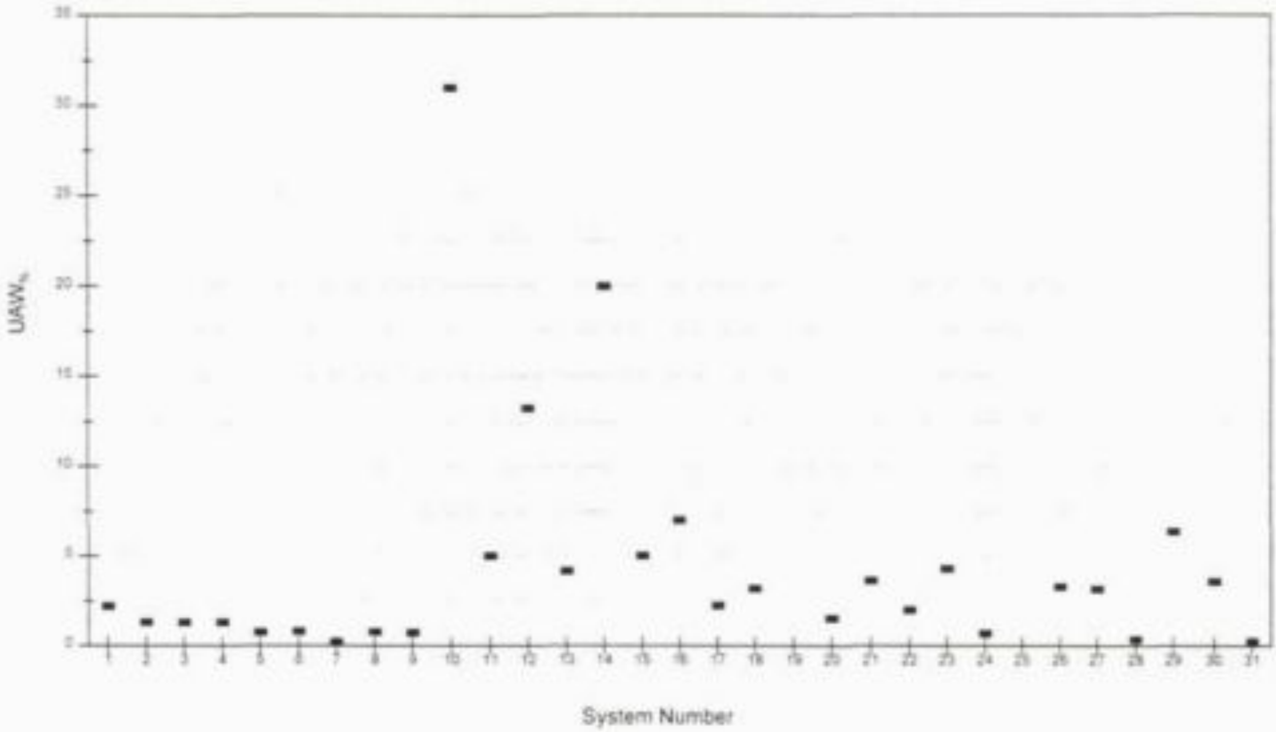


Scatter of $UAW_{\%}$



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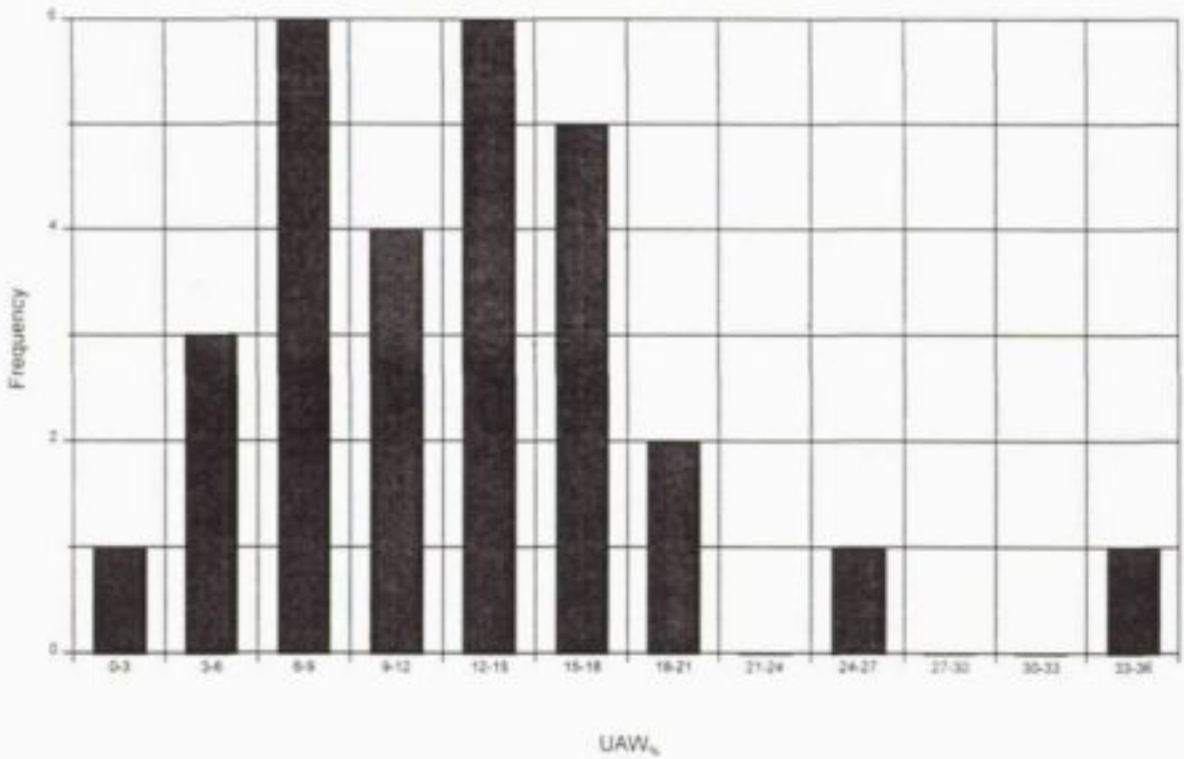


APPENDIX B

IN-SITU METER TESTING

CONTENTS | PAGE

IN-SITU DOMESTIC WATER METER TEST IN JOHANNESBURG

SUBURB : Bezuidenhout Valley and Houghton

DATE : July 1989

INSITU METER TESTING : FIELD DATA SHEET

DATE: ____

SUBURB : ____ METER TYPE : ____

STAND NO. : ____ METER NO. : ____

ADDRESS : ____ METER SIZE : ____

____ POSITION : ____

STAT. PRESSURE : ____ READING : ____

TEST		WEIGHT KG.	TEST FLOW PRESSURE KPa.	INITIAL READING V1	FINAL READING V2	VOLUME V = V1 - V2	TIME	% ERROR

Table 1: Meter Accuracy Flow Rate 10 ℓ/h

	Kent			Castle		
	Houghton	Bez Valley		Houghton	Bez Valley	
	07/89	01/89	8/89	07/89	01/89	08/89
Number of meters	20	14	9	20	28	9
% not recording	0 %	0 %	12 %	0 %	11 %	9 %
% over recording	73 %	64 %	35 %	88 %	68 %	41 %
% under recording	18 %	36 %	24 %	13 %	21 %	50 %
% with no error	10 %	0 %	29 %	0 %	0 %	0 %
% error < 1 %	10 %	7 %	33 %	0 %	0 %	0 %
% error < 2 %	10 %	14 %	33 %	3 %	0 %	0 %
% error < 3 %	10 %	21 %	40 %	5 %	0 %	6 %
% error < 5 %	25 %	36 %	67 %	15 %	12 %	16 %
% error < 10 %	40 %	50 %	73 %	18 %	24 %	19 %
% error > 10 %	60 %	50 %	27 %	83 %	76 %	81 %
Average error	+ 36.4 %	+ 12.4 %	+1.6 %	+ 65 %	+ 22.8 %	- 16.8 %

Table 2: Meter Accuracy Flow Rate 30 ℓ/h

	Kent			Castle		
	Houghton	Bez Valley		Houghton	Bez Valley	
	07/89	01/89	8/89	07/89	01/89	08/89
Number of meters	20	18	9	20	36	18
% not recording	0 %	6 %	11 %	0 %	3 %	3 %
% over recording	75 %	78 %	50 %	93 %	92 %	67 %
% under recording	10 %	11 %	11 %	5 %	6 %	31%
% with no error	15 %	6 %	28 %	3 %	0 %	0 %
% error < 1 %	15 %	6 %	31 %	3 %	3 %	0 %
% error < 2 %	15 %	24 %	31 %	3 %	9 %	0 %
% error < 3 %	15 %	41 %	31 %	6 %	9 %	6 %
% error < 5 %	50 %	41 %	88 %	10 %	20 %	14 %
% error < 10 %	58 %	76 %	100 %	23 %	54 %	56 %
% error > 10 %	43 %	24 %	27 %	78 %	46 %	44 %
Average error	+ 34 %	+ 9.0 %	+2.7 %	+ 40 %	+ 7.8 %	+ 6.5 %

Table 3: Meter Accuracy Flow Rate 150 ℓ/h

	Kent		Castle	
	Houghton	Bez Valley	Houghton	Bez Valley
	07/89	8/89	07/89	08/89
Number of meters	20	9	20	18
% not recording	0 %	11 %	0 %	0 %
% over recording	83 %	67 %	75 %	78 %
% under recording	8 %	11 %	23 %	19%
% with no error	10 %	11 %	3 %	3 %
% error < 1 %	23 %	25 %	18 %	33 %
% error < 2 %	38 %	56 %	35 %	50 %
% error < 3 %	50 %	81 %	43 %	67 %
% error < 5 %	65 %	100 %	55 %	85 %
% error < 10 %	90 %	100 %	90 %	94 %
% error > 10 %	10 %	0 %	10 %	6 %
Average error	+ 6.6 %	+1.6 %	+ 3.7 %	+ 2.2 %

Table 4: Meter Accuracy Flow Rate 600 ℓ/h

	Kent		Castle	
	Houghton	Bez Valley	Houghton	Bez Valley
	07/89	8/89	07/89	08/89
Number of meters	11	9	11	18
% not recording	0 %	11 %	0 %	0 %
% over recording	50 %	72 %	70 %	64 %
% under recording	10 %	17 %	30 %	36 %
% with no error	40 %	0 %	0 %	0 %
% error < 1 %	65 %	25 %	0 %	31 %
% error < 2 %	70 %	38 %	35 %	61 %
% error < 3 %	70 %	69 %	60 %	78 %
% error < 5 %	75 %	88 %	80 %	97 %
% error < 10 %	95 %	100 %	95 %	97 %
% error > 10 %	5 %	0 %	5 %	3 %
Average error	+ 7.3 %	+1.8 %	+ 2.3 %	+ 1.3 %

Table 5: Meter Accuracy Flow Rate > 1000 ℓ/h

	Kent		Castle	
	Houghton	Bez Valley	Houghton	Bez Valley
	07/89	8/89	07/89	08/89
Number of meters	20	9	20	18
% not recording	0 %	5 %	0 %	0 %
% over recording	48 %	58 %	63 %	66 %
% under recording	35 %	23 %	30 %	34 %
% with no error	18 %	14 %	8 %	0 %
% error < 1 %	60 %	71 %	40 %	50 %
% error < 2 %	78 %	90 %	60 %	77 %
% error < 3 %	85 %	90 %	70 %	91 %
% error < 5 %	93 %	95 %	88 %	95 %
% error < 10 %	99 %	100 %	98 %	100 %
% error > 10 %	3 %	0 %	3 %	0 %
Average error	- 0.1 %	+0.3 %	+ 1.6 %	+0.6 %

Table 6: Average of all results of Meter Accuracy
Bezuidenhout Valley and Houghton

	Flows ℓ/h									
	10		30		150		600		>1000	
	Kent	Castle	Kent	Castle	Kent	Castle	Kent	Castle	Kent	Castle
Number of meters	43	57	47	74	29	38	20	29	42	64
% not recording	3 %	7 %	4 %	2 %	3 %	0 %	5 %	0 %	3 %	0 %
% over recording	62 %	71 %	71 %	86 %	78 %	76 %	60 %	66 %	53 %	65 %
% under recording	25 %	23 %	11 %	12 %	9 %	21 %	13 %	34 %	29 %	33 %
% with no error	11 %	0 %	14 %	1 %	10 %	3 %	22 %	0 %	16 %	3 %
% error < 1 %	14 %	0 %	15 %	2 %	24 %	25 %	47 %	19 %	66 %	47 %
% error < 2 %	16 %	1 %	22 %	5 %	44 %	42 %	56 %	51 %	84 %	72 %
% error < 3 %	20 %	3 %	28 %	7 %	60 %	54 %	70 %	71 %	88 %	84 %
% error < 5 %	37 %	14 %	54 %	16 %	76 %	69 %	81 %	91 %	94 %	93 %
% error < 10 %	50 %	21 %	73 %	46 %	93 %	92 %	97%	96 %	99 %	99 %
% error > 10 %	50 %	79 %	27 %	54 %	7 %	8 %	3 %	4 %	1 %	1 %
Average error	+21.3 %	+31.4 %	+18.4 %	+16.2 %	+5.0%	+3.0%	+2.4%	+1.7%	+0.1%	+0.9%

IN-SITU DOMESTIC WATER METER TEST IN PINELANDS

DATE : June - July 1994

Pinelands Town Council

Insitu meter testing - **Domestic meters**

Field data sheet DATE: ______________

Type of Test: **Volumetric** Tested by: ____________________

Meter		**Location**	
Age (Years):		Acc. No:	
Number:		Suburb:	
Make:		Address:	
Model:		Stand No:	
Unit (Kl or Gal):		Company:	
Size (mm):			

Test	**Initial reading V_1**	**Final reading V_2**		**Time (Sec.)**	**Volume Tank V_T**
I					
Slow					
Medium					
Fast					
II					
Slow					
Medium					
Fast					
III					
Slow					
Medium					
Fast					

Comments:

TABLE A: OLD METERS (c. 20 years old)

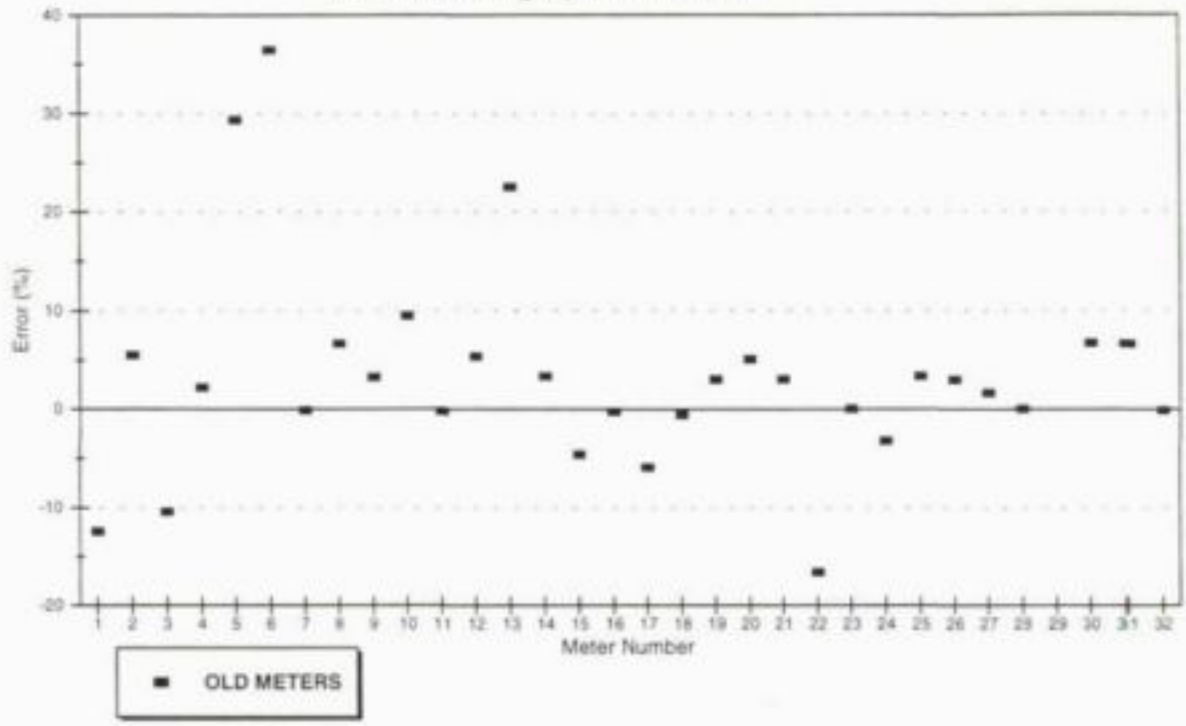
Flow Rate	60ℓ/h	200ℓ/h	Full Bore
Meter No.	Error (%)	Error (%)	Error (%)
1	-12.40	-4.28	0.74
2	5.53	0.17	-7.53
3	-10.40	-1.85	0.11
4	2.25	-0.05	-1.18
5	29.38	4.75	-0.79
6	36.48	18.92	2.22
7	-0.07	-0.13	0.27
8	6.70	-1.80	0.44
9	3.30	-0.10	-1.45
10	9.52	-2.65	0.80
11	-0.20	-0.15	-0.63
12	5.43	2.78	-0.01
13	22.56	8.36	-3.83
14	3.37	1.53	1.10
15	-4.55	-5.05	-6.15
16	-0.25	1.50	-0.72
17	-5.89	3.06	-4.55
18	-0.56	-0.35	1.37
19	3.07	-0.30	-0.71

Flow Rate	60ℓ/h	200ℓ/h	Full Bore
Meter No.	Error (%)	Error (%)	Error (%)
20	5.11	-0.12	0.76
21	3.09	1.57	-0.86
22	-16.54	-0.02	0.76
23	0.07	-0.07	2.14
24	-3.17	-8.42	-1.35
25	3.63	-0.30	-0.23
26	3.00	1.51	-1.33
27	1.66	0.37	-0.36
28	0.03	3.16	-1.33
29	73.33	-0.27	-0.89
30	6.78	1.74	-0.08
31	6.71	1.49	-1.74
32	-0.07	-0.58	1.05
Mean Error (%)	5.52	0.83	-0.75
Mean Error (ℓ/h)	3.31	1.67	-11.18

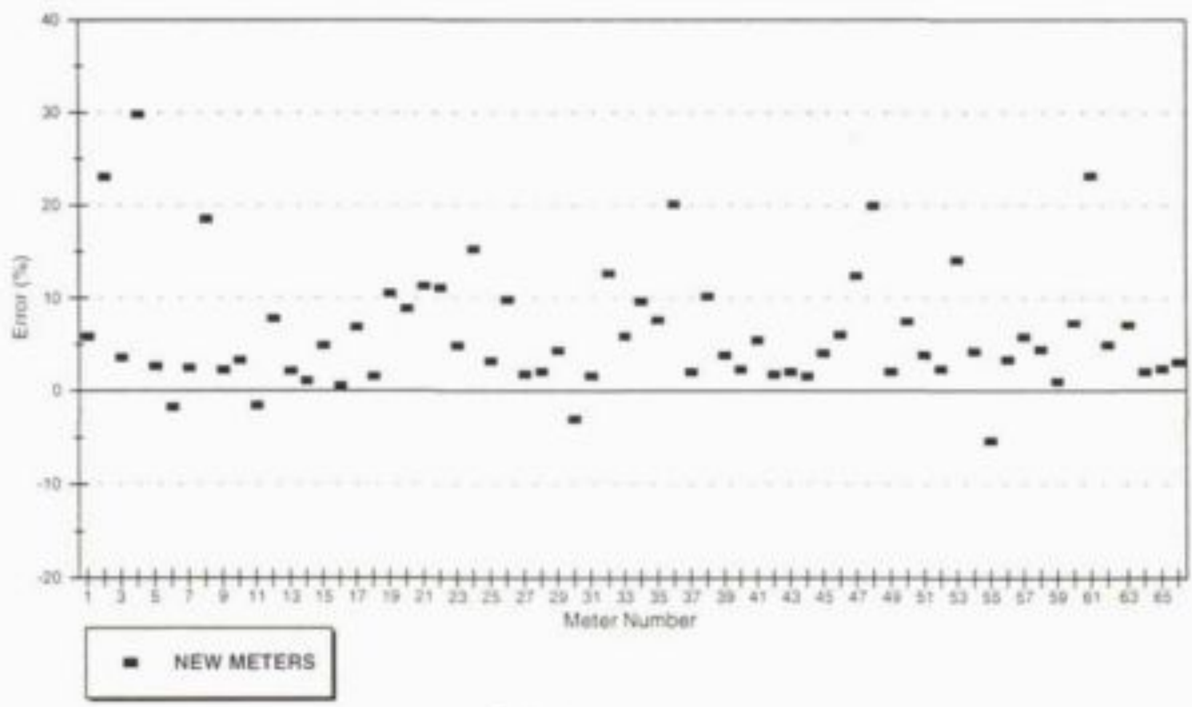
TABLE B: NEW METERS (≤ 2 years old)

Flow Rate	60ℓ/h	200ℓ/h	Full Bore
Meter No.	Error (%)	Error (%)	Error (%)
1	5.87	0.08	-0.99
2	23.12	3.41	1.07
3	3.62	2.08	0.74
4	29.81	1.47	0.58
5	2.68	-0.52	-0.13
6	-1.68	0.80	-0.89
7	2.50	1.48	0.34
8	18.54	1.84	4.94
9	2.31	-0.57	0.21
10	3.33	0.50	0.01
11	-1.52	-0.44	-0.42
12	7.83	1.00	-0.38
13	2.19	-0.63	-0.22
14	1.14	-0.10	0.27
15	4.95	1.95	0.25
16	0.64	3.37	0
17	6.89	1.67	0.35
18	1.61	1.08	0.56
19	10.57	-0.27	0.03
20	8.93	4.19	2.07
21	11.32	2.82	0.48
22	11.14	3.56	1.04
23	4.90	1.49	0.37
24	15.30	4.32	0.81
25	3.26	2.62	0.27
26	9.84	1.38	1.49
27	1.80	0.30	-0.43
28	2.10	0.73	0.84
29	4.38	1.98	1.61
30	-2.98	-1.92	-0.42
31	1.65	0.37	-0.18
32	12.70	1.91	1.27
33	5.93	1.73	0.66
34	9.71	2.73	0.87
35	7.66	0.78	-0.41
36	20.15	2.95	0.89
37	2.07	1.01	-0.30
38	10.24	2.81	0.49
39	3.88	1.56	0.09
40	2.35	2.47	0.32
41	5.46	2.81	1.60
42	1.77	0.76	-0.28
43	2.05	-0.26	-0.12
44	1.60	1.61	0.71
45	4.06	8.78	0.94
46	6.06	3.00	3.78
47	12.45	3.10	0.90
48	19.99	5.73	-0.13
49	2.11	2.55	0.33
50	7.53	2.28	1.18
51	3.87	4.71	0.76
52	12.40	0.83	-0.38
53	14.14	4.42	0.35
54	4.24	10.68	0.55
55	-5.31	0.40	0.38
56	3.36	1.25	0.37
57	5.83	2.32	-0.30
58	4.45	1.96	0.68
59	1.05	0.74	0.35
60	7.30	2.00	0.83
61	23.20	2.74	-0.10
62	4.97	1.50	4.89
63	7.11	1.77	-0.64
64	2.06	0.51	-0.65
65	2.38	1.95	0.82
66	3.08	0.70	-0.49
Mean Error (%)	6.33	1.92	0.52
Mean Error (ℓ/h)	3.80	3.84	7.84

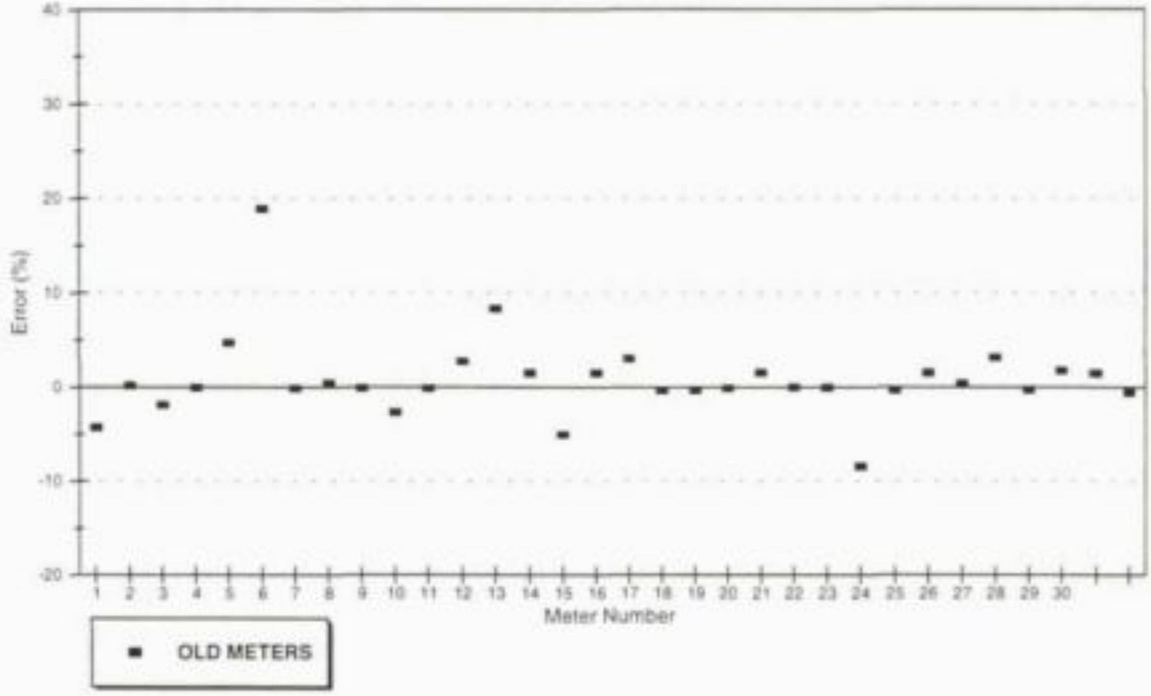
Error scatter graph for Q=60ℓ/h



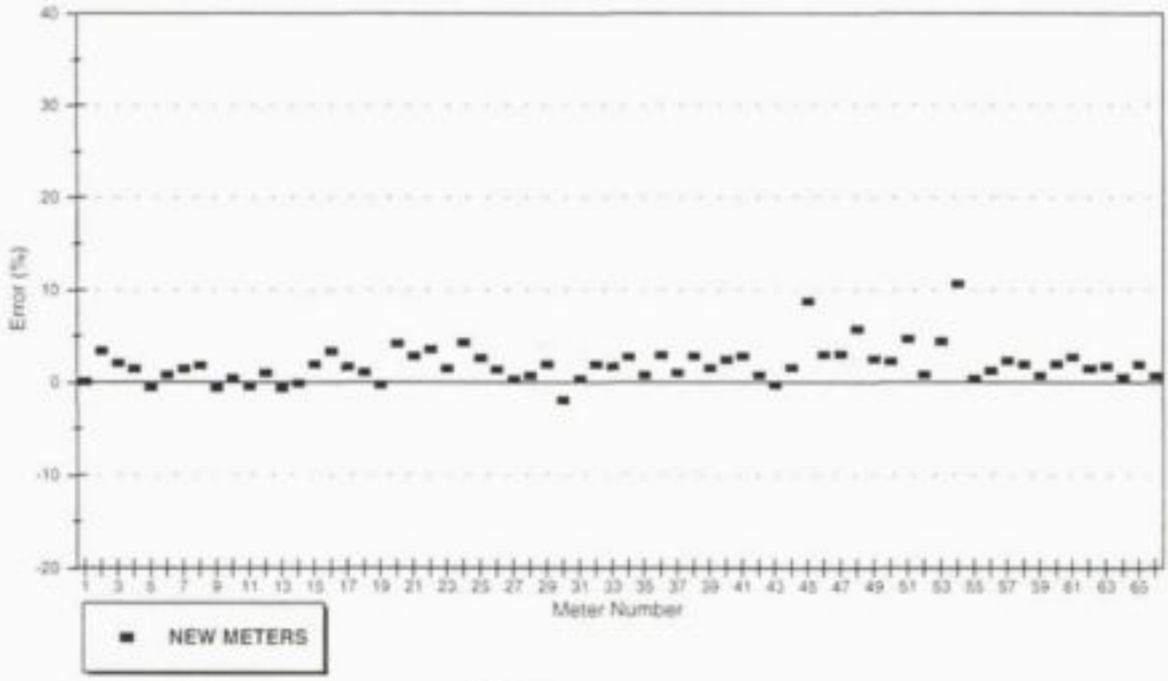
Error scatter graph for Q=60ℓ/h



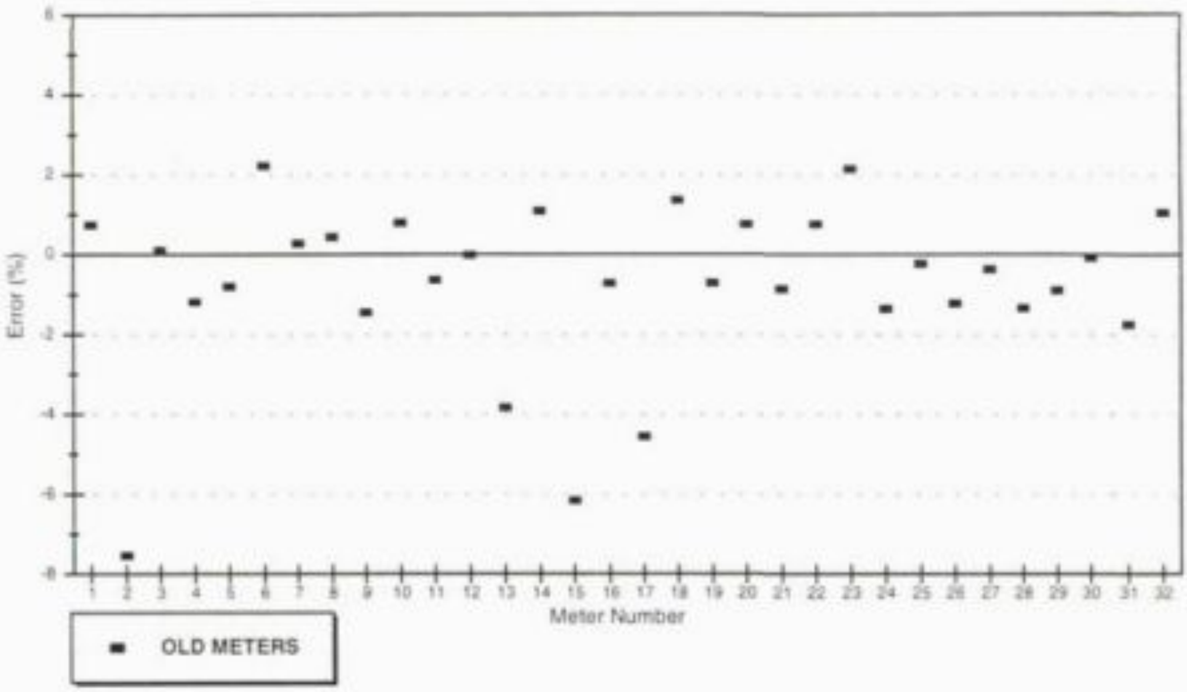
Error Scatter Graph for Q=200ℓ/h



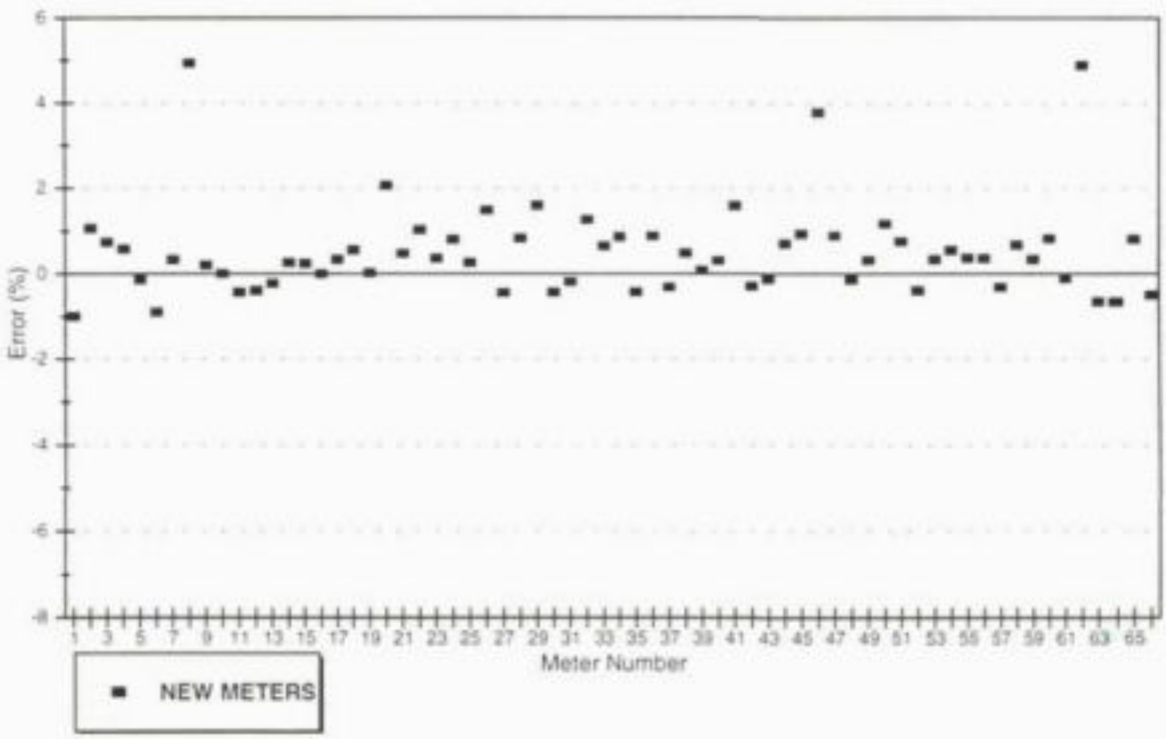
Error Scatter Graph for Q=200ℓ/h



Error Scatter Graph for Q=Full Bore



Error Scatter Graph for Q=Full Bore



IN-SITU DOMESTIC WATER METER TEST IN KEMPTON PARK

SUBURB : Rhodesfield

DATE : May 1995

INSITU METER TESTING

AUTHORITY : KEMPTON PARK CITY COUNCIL

TESTED BY: ____________________

DATE / TEST NO. :

YEAR	MONTH	DAY	NO

CONSUMER DETAILS			
Type	Domestic*	Industrial*	Commercial*
	Other:		
Suburb			
Street & No			
Stand No.			

METER DETAILS		
Make		
Model		
Size		
Number		
Unit	litre*	gal*

REMARKS

TEST TYPE		SLOW (Flow=)	MEDIUM (Flow=)		FAST (Flow=)	
Run No.	Meter	(Time for 1 litre or 5 litre flow in seconds)**	Meter Reading		Meter Reading	
			Initial	Final	Initial	Final
1	Insitu					
	Check					
2	Insitu					
	Check					
3	Insitu					
	Check					

FLOW RANGES (litres/hr)		
Test Type	Meter Size	
	15 mm	20mm
Slow	55-65	110-130
Medium	450-550	900-1100
Fast	1400-1600	2300-2700

* Tick Appropriate Box

** Dependant on Graduation Resolution of Insitu Meter

KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
				Error	Average		Reading		Diff	Error	Average		Reading		Diff	Error	Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
03-01	1	insitu	35,28	18,82		insitu	2317,01615	2317,03116	0,01501	-0,13		insitu					
		check	41,92			check	0,05972	0,07475	0,01503			check					
	2	insitu	26,85	0,71		insitu	7,03915	7,04935	0,01020	-0,39		insitu					
		check	27,04			check	0,08214	0,09238	0,01024			check					
	3	insitu	26,12	4,90		insitu	8,05590	8,06520	0,00930	-0,21		insitu					
		check	27,40		8,14	check	0,09860	0,10792	0,00932		-0,25	check					
03-02	1	insitu	30,42	2,41		insitu	6,06470	6,07350	0,00880	-0,56		insitu	15960,03570	15960,05100	0,01530	13,42	
		check	31,15			check	0,21900	0,22785	0,00885			check	0,19706	0,21055	0,01349		
	2	insitu	34,40	11,50		insitu	6,13320	6,14700	0,01380	-0,07		insitu					
		check	38,35			check	0,28798	0,30179	0,01381			check					
	3	insitu	27,29	-0,37		insitu	6,19610	6,20950	0,01340	1,28		insitu	6,17610	6,19400	0,01790	0,73	
		check	27,19		4,52	check	0,33924	0,35247	0,01323		0,22	check	0,31925	0,33702	0,01777		7,07
03-03	1	insitu	22,76			insitu	2,67240	2,68500	0,01260	4,91		insitu					
		check				check	0,41700	0,42901	0,01201			check					
	2	insitu				insitu						insitu					
		check				check						check					
	3	insitu				insitu						insitu					
		check			0,00	check					1,64	check					
03-04	1	insitu	27,83	0,92		insitu	2,96860	2,98100	0,01240	0,90		insitu					
		check	28,09			check	0,46301	0,47530	0,01229			check					
	2	insitu	28,00	-3,66		insitu	2,98900	3,00050	0,01150	-2,29		insitu					
		check	26,97			check	0,48436	0,49613	0,01177			check					
	3	insitu	28,11	3,11		insitu	3,01200	3,02630	0,01430	-0,28		insitu					
		check	28,98		0,12	check	0,50701	0,52135	0,01434		-0,56	check					
03-05	1	03-05	49,85	7,26		insitu	2,24130	2,25510	0,01380	2,99		insitu					
		check	53,47			check	0,54836	0,56176	0,01340			check					
	2	insitu	55,50	9,06		insitu	2,26330	2,27580	0,01250	-0,08		insitu					
		check	60,53			check	0,56943	0,58194	0,01251			check					
	3	insitu	59,91	7,66		insitu	2,28370	2,29570	0,01200	2,30		insitu					
		check	64,50		8,00	check	0,58930	0,60103	0,01173		1,74	check					
03-06	1	insitu	53,67	4,97		insitu	2,97000	2,98480	0,01480	1,09		insitu					
		check	56,34			check	0,62782	0,64246	0,01464			check					
	2	insitu	62,72	4,93		insitu	2,99170	3,00730	0,01560	-0,51		insitu					
		check	65,81			check	0,64930	0,66498	0,01568			check					
	3	insitu	53,71	2,12		insitu	3,01380	3,02490	0,01110	2,21		insitu					
		check	54,85		4,01	check	0,67141	0,68227	0,01086		0,93	check					
03-07	1	insitu	64,03	-0,56		insitu	5,91500	5,92630	0,01130	-2,42		insitu					
		check	63,67			check	0,71673	0,72831	0,01158			check					
	2	insitu	49,65	3,16		insitu	5,93400	5,94620	0,01220	-1,37		insitu					
		check	51,22			check	0,73608	0,74845	0,01237			check					
	3	insitu	70,72	-1,70		insitu	5,95710	5,96580	0,00870	-25,89		insitu					
		check	69,52		0,30	check	0,75949	0,77123	0,01174		-9,90	check					
03-08	1	insitu	69,03	2,09		insitu	4,82170	4,83570	0,01400	3,24		insitu					
		check	70,47			check	0,79012	0,80368	0,01356			check					
	2	insitu	71,90	-3,14		insitu	4,84220	4,85470	0,01250	2,46		insitu					
		check	69,64			check	0,81038	0,82258	0,01220			check					
	3	insitu	74,46	-4,36		insitu	4,86060	4,87300	0,01240	1,39		insitu					
		check	71,21		-1,81	check	0,82866	0,84089	0,01223		2,36	check					

KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
			s/l	Error %	Average		Reading Initial	Final	Diff kl	Error %	Average		Reading Initial	Final	Diff kl	Error %	Average
03-09	1	insitu	30,16	2,47		insitu	1,87890	1,89230	0,01340	-10,84		insitu					
		check	30,90			check	0,85866	0,87200	0,01503			check					
	2	insitu	35,25	-3,02		insitu	1,89950	1,91150	0,01340	11,30		insitu					
		check	34,18			check	0,87907	0,89111	0,01204			check					
	3	insitu	28,67	-1,74		insitu	1,91880	1,93100	0,01220	-0,97		insitu					
		check	28,17		-0,77	check	0,89823	0,91055	0,01232		-0,17	check					
03-10	1	insitu	53,90	46,38		insitu	8,44430	8,45830	0,01400	4,40		insitu					
		check	78,90			check	0,92671	0,94012	0,01341			check					
	2	insitu	57,78	30,15		insitu	8,47080	8,48560	0,01480	5,11		insitu					
		check	75,20			check	0,94900	0,96308	0,01408			check					
	3	insitu	59,40	44,04		insitu	8,49320	8,50660	0,01340	3,88		insitu					
		check	85,56		40,19	check	0,96872	0,98162	0,01290		4,46	check					
10-01	1	insitu	28,46	19,18		insitu	5,15895	5,17877	0,01982	5,71		insitu					
		check	33,92			check	1,04545	1,06420	0,01875			check					
	2	insitu	23,37	20,03		insitu	5,19130	5,20356	0,01226	1,24		insitu					
		check	28,05			check	1,07504	1,08715	0,01211			check					
	3	insitu	22,36	20,57		insitu	5,21195	5,22605	0,01410	-4,73		insitu					
		check	26,96		19,93	check	1,09431	1,10911	0,01480		0,74	check					
10-02	1	insitu	23,96	25,79		insitu	9,05560	9,07530	0,01970	33,11		insitu					
		check	30,14			check	1,12392	1,13872	0,01480			check					
	2	insitu	28,36	2,79		insitu	9,10160	9,11750	0,01590	111,16		insitu					
		check	29,15			check	1,16128	1,16881	0,00753			check					
	3	insitu	28,26	2,87		insitu	9,12370	9,13780	0,01410	2,77		insitu					
		check	29,07		10,48	check	1,17402	1,18774	0,01372		49,01	check					
10-03	1	insitu	23,30	7,94		insitu	0,08071	0,09881	0,01810	21,64		insitu					
		check	25,15			check	1,23423	1,24911	0,01488			check					
	2	insitu	22,11	9,68		insitu	0,10485	0,11885	0,01400	1,60		insitu					
		check	24,25			check	1,25774	1,27152	0,01378			check					
	3	insitu	23,68	8,15		insitu	0,12636	0,13734	0,01098	1,86		insitu					
		check	25,61		8,59	check	1,27873	1,28951	0,01078		8,36	check					
10-04	1	insitu	24,86	23,37		insitu	1,50110	1,51400	0,01290	14,77		insitu					
		check	30,67			check	1,32294	1,33418	0,01124			check					
	2	insitu	32,87	8,21		insitu	1,52250	1,53220	0,00970	3,41		insitu					
		check	35,57			check	1,34204	1,35142	0,00938			check					
	3	insitu	26,96	19,10		insitu	1,53920	1,55000	0,01080	2,76		insitu					
		check	32,11		16,90	check	1,35770	1,36821	0,01051		6,98	check					
10-05	1	insitu	34,18	5,41		insitu	7,10919	7,12802	0,01883	0,59		insitu					
		check	36,03			check	1,38072	1,39944	0,01872			check					
	2	insitu	34,00	5,18		insitu	7,13679	7,14884	0,01205	0,08		insitu					
		check	35,76			check	1,40804	1,42008	0,01204			check					
	3	insitu	42,35	9,63		insitu	7,15556	7,16813	0,01257	-0,08		insitu					
		check	46,43		6,74	check	1,42673	1,43931	0,01258		0,20	check					
10-06	1	insitu	29,52	8,30		insitu	9,90920	9,91740	0,00820	-21,61		insitu					
		check	31,97			check	1,46449	1,47495	0,01046			check					
	2	insitu	37,62	1,17		insitu	9,92990	9,94170	0,01180	0,25		insitu					
		check	38,06			check	1,48511	1,49688	0,01177			check					
	3	insitu	33,65	10,25		insitu	9,95000	9,96200	0,01200	0,08		insitu					
		check	37,10		6,57	check	1,50473	1,51672	0,01199		-7,09	check					

KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow		Error	Average	Medium	Reading		Diff	Error	Average	Fast	Reading		Diff	Error	Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
10-07	1	insitu	35,15	4,98		insitu	1,79740	1,81241	0,01501	-1,44		insitu					
		check	36,90			check	1,54112	1,55635	0,01523			check					
	2	insitu	33,11	8,82		insitu	1,81830	1,82958	0,01128	-2,08		insitu					
		check	36,03			check	1,56240	1,57392	0,01152			check					
	3	insitu	29,49	4,31		insitu	1,83538	1,84750	0,01212	-2,10		insitu					
		check	30,76		6,03	check	1,57984	1,59222	0,01238		-1,88	check					
10-08	1	insitu	32,48	16,66		insitu	5,65450	5,66990	0,01540	3,49		insitu					
		check	37,89			check	1,61697	1,63185	0,01488			check					
	2	insitu	27,41	16,34		insitu	5,67560	5,68530	0,00970	2,21		insitu					
		check	31,89			check	1,63760	1,64709	0,00949			check					
	3	insitu	31,55	12,01		insitu	5,69240	5,70260	0,01020	3,76		insitu					
		check	35,34		15,00	check	1,65446	1,66429	0,00983		3,16	check					
10-09	1	insitu	33,43	7,38		insitu	7,23116	7,24496	0,01380	-7,38		insitu					
		check	35,96			check	1,68544	1,70034	0,01490			check					
	2	insitu	38,67	11,40		insitu	7,25130	7,26453	0,01323	-0,53		insitu					
		check	43,08			check	1,70664	1,71994	0,01330			check					
	3	insitu	26,33	11,70		insitu	7,27075	7,28436	0,01361	-0,58		insitu					
		check	29,41		10,16	check	1,72602	1,73971	0,01369		-2,83	check					
10-10	1	insitu				insitu	5,46000	5,73000	0,27000	1883,84		insitu					
		check				check	1,78295	1,79656	0,01361			check					
	2	insitu				insitu						insitu					
		check				check						check					
	3	insitu				insitu						insitu					
		check				check						check					
10-11	1	insitu	33,59	10,30		insitu	5,93550	5,94900	0,01350	3,21		insitu					
		check	37,05			check	1,81678	1,82986	0,01308			check					
	2	insitu	33,03	4,98		insitu	5,95830	5,97100	0,01270	1,52		insitu					
		check	37,03			check	1,83911	1,85162	0,01251			check					
	3	insitu	34,08	12,24		insitu	5,97800	5,98700	0,00900	-3,85		insitu					
		check	38,25		9,17	check	1,85849	1,86785	0,00936		0,29	check					
10-12	1	insitu	21,46	57,08		insitu	2,52800	2,54010	0,01210	25,39		insitu					
		check	33,71			check	1,88586	1,89551	0,00965			check					
	2	insitu	18,13	54,72		insitu	2,56020	2,57460	0,01440	8,68		insitu					
		check	28,05			check	1,90926	1,92251	0,01325			check					
	3	insitu	21,17	59,18		insitu						insitu					
		check	33,69		56,99	check					17,03	check					
18-01	1	insitu	44,40	15,61		insitu	1,40900	1,42030	0,01130	2,17		insitu					
		check	51,33			check	1,94540	1,95646	0,01106			check					
	2	insitu	33,14	3,08		insitu	1,43110	1,44390	0,01280	1,19		insitu					
		check	34,16			check	1,96676	1,97941	0,01265			check					
	3	insitu	36,28	3,58		insitu	1,45150	1,46420	0,01270	-6,27		insitu					
		check	37,58		7,42	check	1,98650	2,00005	0,01355		-0,97	check					
18-02	1	insitu	30,39	0,63		insitu	4,65600	4,66700	0,01100	-3,42		insitu					
		check	30,58			check	2,01765	2,02904	0,01139			check					
	2	insitu	31,00	19,10		insitu	4,65900	4,69230	0,03330	103,79		insitu					
		check	36,92			check	2,03748	2,05382	0,01634			check					
	3	insitu	34,00	7,85		insitu	4,69730	4,70820	0,01090	4,51		insitu					
		check	36,67		9,19	check	2,05925	2,06968	0,01043		34,96	check					

KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow		Slow Error	Slow Average	Medium	Medium Reading		Medium Diff	Medium Error	Medium Average	Fast	Fast Reading		Fast Diff	Fast Error	Fast Average
			sl	%			Initial	Final	kl	%			Initial	Final	kl	%	
18-03	1	insitu	35,79	6,90		insitu	0,77200	0,78720	0,01520	0,73		insitu					
		check	38,26			check	2,08736	2,10245	0,01509			check					
	2	insitu	37,56	-3,19		insitu	0,78750	0,80450	0,01700	7,53		insitu					
		check	36,36			check	2,10245	2,11826	0,01581			check					
	3	insitu	36,66	-2,51		insitu	0,81100	0,82560	0,01460	-0,41		insitu					
		check	35,74		0,40	check	2,12405	2,13871	0,01466		2,62	check					
18-04	1	insitu	75,53	-38,94		insitu	5,71706	5,73084	0,01378	-1,22		insitu					
		check	46,12			check	2,16479	2,17874	0,01395			check					
	2	insitu	37,23	-15,42		insitu	5,73467	5,74586	0,01119	-1,06		insitu					
		check	31,49			check	2,18455	2,19586	0,01131			check					
	3	insitu	50,62	-23,39		insitu	5,75510	5,76910	0,01400	-1,69		insitu					
		check	38,78		-25,92	check	2,20210	2,21634	0,01424		-1,32	check					
18-05	1	insitu	33,58	7,86		insitu	8,70410	8,72060	0,01650	2,17		insitu					
		check	36,22			check	2,24841	2,26456	0,01615			check					
	2	insitu	31,47	3,84		insitu	8,73510	8,74510	0,01000	-0,10		insitu					
		check	32,68			check	2,27864	2,28865	0,01001			check					
	3	insitu	33,27	3,10		insitu	8,82200	8,83400	0,01200	-3,15		insitu					
		check	34,30		4,93	check	2,36416	2,37655	0,01239		-0,36	check					
18-06	1	insitu	39,62	2,35		insitu	6,84845	6,86532	0,01687	-0,41		insitu					
		check	40,55			check	2,39585	2,41279	0,01694			check					
	2	insitu	39,22	3,62		insitu	6,86929	6,88121	0,01192	8,46		insitu					
		check	40,64			check	2,41773	2,42872	0,01099			check					
	3	insitu	24,93	1,60		insitu	6,88730	6,89926	0,01196	-0,50		insitu					
		check	25,33		2,52	check	2,43479	2,44681	0,01202		2,52	check					
18-07	1	insitu	30,83	-8,24		insitu	2,09580	2,10810	0,01230	-1,20		insitu					
		check	28,29			check	2,47352	2,48597	0,01245			check					
	2	insitu	28,97	2,24		insitu	2,11390	2,12780	0,01390	-2,46		insitu					
		check	29,62			check	2,49112	2,50537	0,01425			check					
	3	insitu	29,98	-3,42		insitu	2,13680	2,14750	0,01070	1,04		insitu					
		check	28,96		-3,14	check	2,51455	2,52514	0,01059		-0,87	check					
18-08	1	insitu	30,82	1,36		insitu	4,60600	4,61900	0,01300	6,56		insitu					
		check	31,24			check	2,54834	2,56054	0,01220			check					
	2	insitu	33,73	-5,22		insitu	4,62580	4,63470	0,00890	1,48		insitu					
		check	31,97			check	2,56708	2,57585	0,00877			check					
	3	insitu	30,08	-0,80		insitu	4,64080	4,65230	0,01150	-0,78		insitu					
		check	29,84		-1,55	check	2,58179	2,59338	0,01159		2,42	check					
18-09	1	insitu	32,13	4,08		insitu	9,20190	9,21480	0,01290	0,31		insitu					
		check	33,44			check	2,61446	2,62732	0,01286			check					
	2	insitu	29,74	1,14		insitu	9,22000	9,23290	0,01290	0,47		insitu					
		check	30,08			check	2,63245	2,64529	0,01284			check					
	3	insitu	30,24	-2,71		insitu	9,23690	9,24760	0,01070	2,29		insitu					
		check	29,42		0,84	check	2,64925	2,65971	0,01046		1,02	check					
18-10	1	insitu	30,93	-1,29		insitu	4,21990	4,23100	0,01110	-0,89		insitu					
		check	30,53			check	2,67623	2,68743	0,01120			check					
	2	insitu	34,13	7,24		insitu	4,23610	4,24900	0,01290	1,98		insitu					
		check	36,60			check	2,69287	2,70552	0,01265			check					
	3	insitu	24,59	-1,83		insitu	4,25300	4,26250	0,00950	0,00		insitu					
		check	24,14		1,37	check	2,70950	2,71900	0,00950		0,36	check					

KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
			kl	Error %	Average		Reading Initial	Final	Diff kl	Error %	Average		Reading Initial	Final	Diff kl	Error %	Average
18-11	1	insitu	28.76	2.43		insitu	8,13000	8,15970	0.02970	130,95		insitu					
		check	29.46			check	2,73712	2,74998	0.01286			check					
	2	insitu	26.64	10.32		insitu	8,16500	8,17490	0.00990	1,33		insitu					
		check	29.39			check	2,75559	2,76536	0.00977			check					
	3	insitu	31,26	3.13		insitu	8,18000	8,18840	0.00840	2,07		insitu					
		check	32,24		5,30	check	2,77061	2,77884	0.00823		44,78	check					
18-12	1	insitu	30,04	3,33		insitu	1,92620	1,94220	0,01600	0,69		insitu					
		check	31,04			check	2,79666	2,81255	0,01589			check					
	2	insitu	28,93	2,28		insitu	1,94660	1,95540	0,00880	-1,46		insitu					
		check	29,59			check	2,81672	2,82565	0,00893			check					
	3	insitu	25,49	6,98		insitu	1,95940	1,96890	0,00950	-11,71		insitu					
		check	27,27		4,20	check	2,82914	2,83990	0,01076		-4,10	check					
18-13	1	insitu	25,77	18,04		insitu	6,32920	6,34120	0,01200	10,29		insitu					
		check	30,42			check	2,86190	2,87278	0,01088			check					
	2	insitu	23,15	42,76		insitu	6,34560	6,35620	0,01060	7,07		insitu					
		check	33,05			check	2,87646	2,88636	0,00990			check					
	3	insitu	24,50	22,16		insitu	6,36090	6,37100	0,01010	10,75		insitu					
		check	29,93		27,66	check	2,89042	2,89954	0,00912		9,37	check					
18-14	1	insitu	41,56	18,79		insitu	8,32680	8,33864	0,01184	1,28		insitu					
		check	49,37			check	2,96050	2,97219	0,01169			check					
	2	insitu	35,39	-3,16		insitu	8,34624	8,35689	0,01065	2,50		insitu					
		check	34,27			check	2,97839	2,98878	0,01039			check					
	3	insitu	27,26	16,36		insitu	8,36191	8,37245	0,01054	1,93		insitu					
		check	31,72		10,66	check	2,99280	3,00314	0,01034		1,91	check					
18-15	1	insitu	18,75	10,88		insitu	6,16570	6,17400	0,00830	-15,99		insitu					
		check	20,79			check	3,02342	3,03330	0,00988			check					
	2	insitu	26,42	-10,79		insitu	6,18060	6,19020	0,00960	3,00		insitu					
		check	23,57			check	3,03940	3,04872	0,00932			check					
	3	insitu	26,80	12,99		insitu	6,19690	6,20570	0,00880	1,15		insitu					
		check	30,28		4,36	check	3,05498	3,06368	0,00870		-3,95	check					
18-16	1	insitu	45,40	1,50		insitu	7,12540	7,13565	0,01025	-9,69		insitu					
		check	46,08			check	3,09764	3,10899	0,01135			check					
	2	insitu	26,66	0,83		insitu	7,14249	7,15060	0,00811	-13,17		insitu					
		check	26,88			check	3,11376	3,12310	0,00934			check					
	3	insitu	23,55	1,06		insitu	7,15590	7,17680	0,02090	-1,79		insitu					
		check	23,80		1,13	check	3,12841	3,14969	0,02128		-8,22	check					
19-01	1	insitu	35,94	0,64		insitu	8,83990	8,84910	0,00920	-4,76		insitu					
		check	36,17			check	3,19572	3,20538	0,00966			check					
	2	insitu	37,49	-4,24		insitu	8,84940	8,87130	0,02190	-15,64		insitu					
		check	35,90			check	3,20896	3,23492	0,02596			check					
	3	insitu	27,77	17,14		insitu	8,87750	8,89350	0,01600	-1,60		insitu					
		check	32,53		4,51	check	3,24004	3,25630	0,01626		-7,33	check					
19-02	1	insitu	27,83	-8,87		insitu	1,61300	1,62500	0,01200	17,07		insitu					
		check	25,36			check	3,27380	3,28405	0,01025			check					
	2	insitu	27,79	-2,07		insitu	1,63000	1,64500	0,01500	18,11		insitu					
		check	27,21			check	3,30628	3,31898	0,01270			check					
	3	insitu				insitu	1,64500	1,66400	0,01900	-2,96		insitu					
		check			-3,65	check	3,31898	3,33856	0,01958		10,74	check					

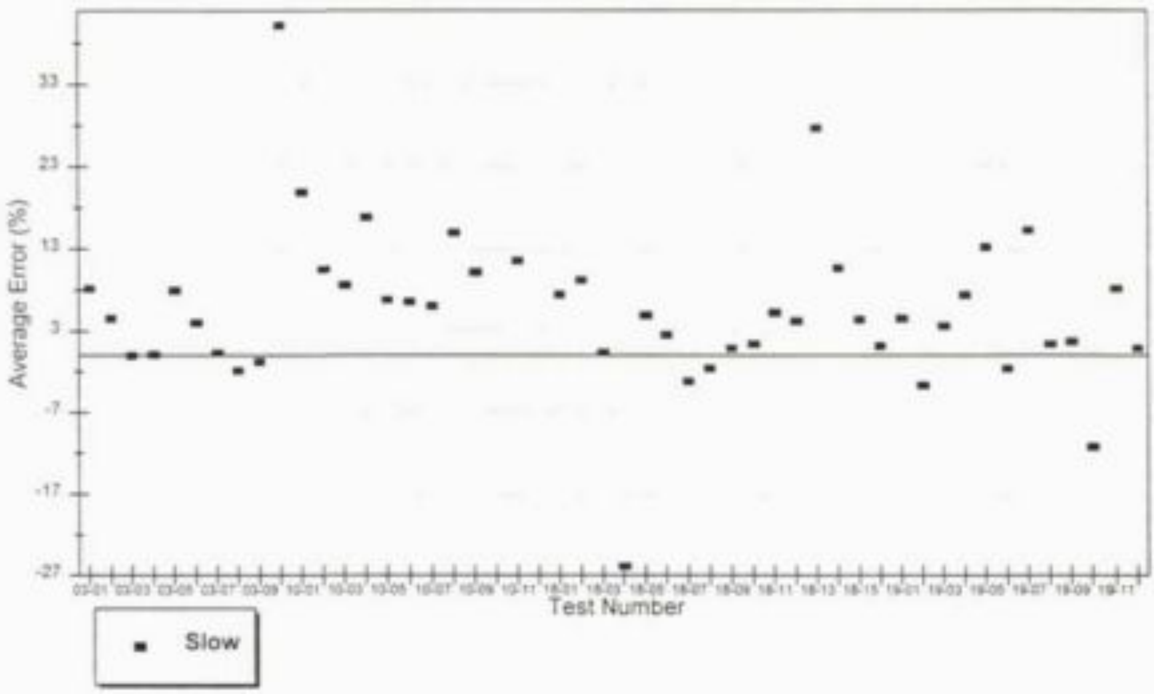
KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow		Error	Average	Medium	Reading		Diff	Error	Average	Fast	Reading		Diff	Error	Average
			l	%			Initial	Final	kl	%			Initial	Final	kl	%	
19-03	1	insitu	27,49	5,86		insitu	7,58170	7,59320	0,01150	-3,52		insitu					
		check	29,10			check	3,36928	3,38120	0,01192			check					
	2	insitu	38,83	3,45		insitu	7,59870	7,60900	0,01030	-3,01		insitu					
		check	40,17			check	3,38638	3,39700	0,01062			check					
	3	insitu	28,18	1,45		insitu	7,61290	7,62720	0,01430	50,05		insitu					
		check	28,59		3,59	check	3,40091	3,41044	0,00953		14,51	check					
19-04	1	insitu	33,95	-0,59		insitu	2,58680	2,59490	0,00810	-20,35		insitu					
		check	33,75			check	3,43028	3,44045	0,01017			check					
	2	insitu	23,46	9,38		insitu	2,60090	2,61440	0,01350	-4,53		insitu					
		check	25,66			check	3,44586	3,46000	0,01414			check					
	3	insitu	23,72	13,28		insitu	2,61870	2,62950	0,01080	1,69		insitu					
		check	26,87		7,36	check	3,46449	3,47511	0,01062		-7,73	check					
19-05	1	insitu	27,84	14,19		insitu	9,68600	9,70700	0,02100	52,17		insitu					
		check	31,79			check	3,49862	3,51242	0,01380			check					
	2	insitu				insitu	9,77500	9,79000	0,01500	22,85		insitu					
		check				check	3,53659	3,54880	0,01221			check					
	3	insitu	18,41	25,36		insitu	9,79000	9,80500	0,01500	10,13		insitu					
		check	23,08		13,16	check	3,54880	3,56242	0,01362		28,39	check					
19-06	1	insitu	30,62	-3,56		insitu	2,47350	2,48850	0,01500	0,00		insitu					
		check	29,53			check	3,58965	3,60465	0,01500			check					
	2	insitu				insitu	2,49370	2,50320	0,00950	-1,76		insitu					
		check				check	3,60968	3,61935	0,00967			check					
	3	insitu	24,87	-1,29		insitu	2,50770	2,51830	0,01060	-4,25		insitu					
		check	24,55		-1,62	check	3,62382	3,63489	0,01107		-2,00	check					
19-07	1	insitu	20,63	3,00		insitu	3,97500	3,98500	0,01000	7,99		insitu					
		check	21,25			check	3,66598	3,67524	0,00926			check					
	2	insitu	24,02	15,53		insitu	4,00200	4,01800	0,01600	77,58		insitu					
		check	27,75			check	3,69430	3,70331	0,00901			check					
	3	insitu	20,93	27,25		insitu	4,03500	4,04500	0,01000	-17,49		insitu					
		check	26,63		15,26	check	3,72069	3,73281	0,01212		22,69	check					
19-08	1	insitu	29,01	3,58		insitu	8,90190	8,91220	0,01030	-1,81		insitu					
		check	30,05			check	3,77808	3,78857	0,01049			check					
	2	insitu	23,12	7,96		insitu	8,91600	8,92890	0,01290	1,26		insitu					
		check	24,96			check	3,79258	3,80532	0,01274			check					
	3	insitu	27,50	-7,49		insitu	8,94120	8,95340	0,01220	0,08		insitu					
		check	25,44		1,35	check	3,80788	3,82007	0,01219		-0,16	check					
19-09	1	insitu	24,21	5,48		insitu	5,54800	5,56300	0,01500	30,10		insitu					
		check	25,54			check	3,84147	3,85300	0,01153			check					
	2	insitu	25,33	-0,36		insitu	5,60000	5,61500	0,01500	29,76		insitu					
		check	25,24			check	3,86901	3,88057	0,01156			check					
	3	insitu				insitu	5,62800	5,64000	0,01200	12,68		insitu					
		check			1,71	check	3,89735	3,90800	0,01065		24,16	check					
19-10	1	insitu	26,64	-11,64		insitu	6,06130	6,07220	0,01090	-3,96		insitu					
		check	23,54			check	3,92900	3,94035	0,01135			check					
	2	insitu	36,62	-20,97		insitu	6,07650	6,08520	0,00870	-4,81		insitu					
		check	28,94			check	3,94482	3,95396	0,00914			check					
	3	insitu	32,61	-0,89		insitu	6,08950	6,10050	0,01100	-0,63		insitu					
		check	32,32		-11,17	check	3,95860	3,96967	0,01107		-3,14	check					

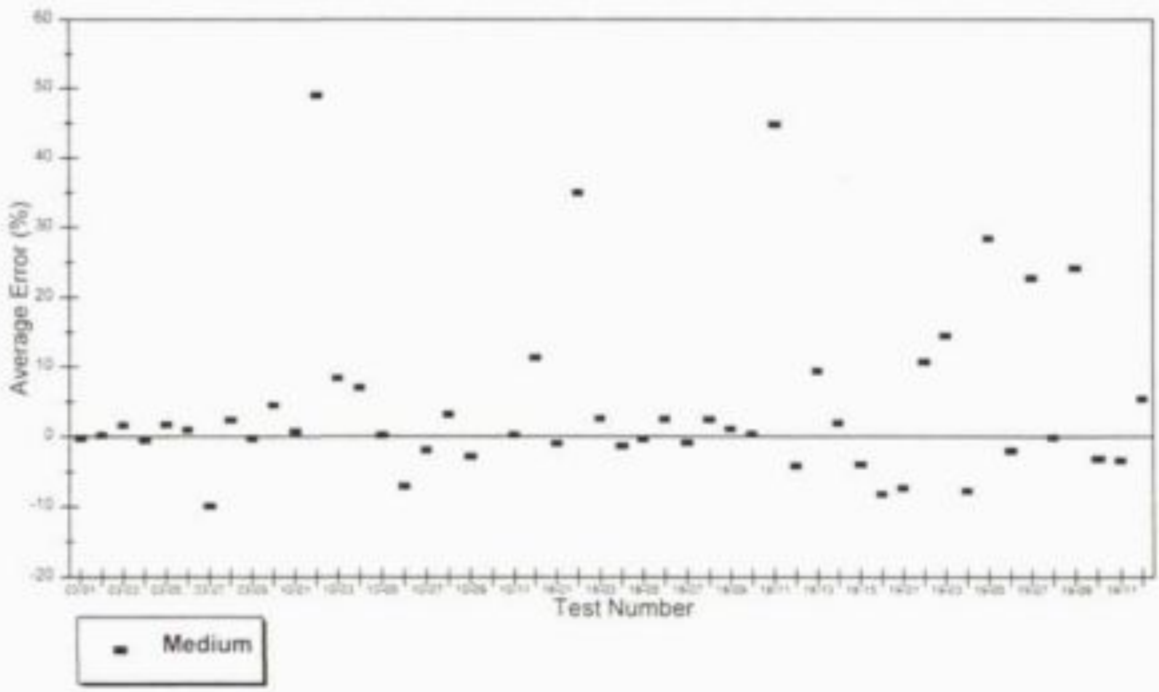
KEMPTON PARK CITY COUNCIL - INSITU METER TESTING

Test No.	Run No.	Slow		Slow Error	Slow Average	Medium	Medium Reading		Medium Diff	Medium Error	Medium Average	Fast	Fast Reading		Fast Diff	Fast Error	Fast Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
19-11	1	insitu	25.05	14.73		insitu	3.07750	3.09150	0.01400	1.97		insitu					
		check	28.74			check	3.98577	3.99950	0.01373			check					
	2	insitu	29.77	9.10		insitu	3.09640	3.10750	0.01110	-14.09		insitu					
		check	32.48			check	4.00424	4.01716	0.01292			check					
	3	insitu	24.70	0.57		insitu	3.11640	3.12630	0.00990	1.96		insitu					
		check	24.84		8.13	check	4.02371	4.03342	0.00971		-3.39	check					
19-12	1	insitu	28.71	22.92		insitu	8.43400	8.44500	0.01100	16.16		insitu					
		check	35.30			check	4.06387	4.07334	0.00947			check					
	2	insitu	32.16	-8.66		insitu	8.46200	8.47400	0.01200	9.69		insitu					
		check	29.38			check	4.08981	4.10075	0.01094			check					
	3	insitu	30.11	-11.77		insitu	8.49400	8.50300	0.00900	-9.73		insitu					
		check	26.57		0.83	check	4.11887	4.12884	0.00997		5.37	check					

Errors scatter graph



Errors scatter graph



IN-SITU DOMESTIC WATER METER TEST IN DURBAN

SUBURB : Reservoir Hills

DATE : June - August 1995

INSITU METER TESTING

AUTHORITY : DURBAN CORPORATION

TESTED BY: ______________________

DATE / TEST NO. :

YEAR	MONTH	DAY	NO

CONSUMER DETAILS			
Type	Domestic*	Industrial*	Commercial*
	Other:		
Suburb			
Street & No			
Stand No.			

METER DETAILS		
Make		
Model		
Size		
Number		
Unit	litre*	gal*

REMARKS

TEST TYPE		SLOW (Flow=)		MEDIUM (Flow=)		FAST (Flow=)	
Run No.	Meter	(Time for 1 litre or 5 litre flow in seconds)**		Meter Reading		Meter Reading	
				Initial	Final	Initial	Final
1	Insitu						
	Check						
2	Insitu						
	Check						
3	Insitu						
	Check						

FLOW RANGES (litres/hr)		
Test Type	Meter Size	
	15 mm	20mm
Slow	55-65	110-130
Medium	450-550	900-1100
Fast	1400-1600	2300-2700

* Tick Appropriate Box

** Dependant on Graduation Resolution of Insitu Meter

DURBAN CORPORATION - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
				Error	Average		Reading		Diff	Error	Average		Reading		Diff	Error	Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
14-01	1	insitu	21,59	2,04		insitu	3,60300	3,61400	0.01100	6,59		insitu					
		check	22,03			check	4,20716	4,21748	0,01032			check					
	2	insitu	31,25	6,78		insitu	3,63500	3,64440	0,00940	3,98		insitu					
		check	33,37			check	4,23700	4,24604	0,00904			check					
	3	insitu	29,34	-2,15		insitu	3,65500	3,66570	0,01070	-3,08		insitu					
		check	28,71		2,22	check	4,25626	4,26730	0,01104		2,50	check					
14-02	1	insitu	29,69	8,29		insitu	0,39490	0,40540	0,01050	-3,40		insitu					
		check	32,15			check	4,28840	4,29927	0,01087			check					
	2	insitu	42,96	4,86		insitu	0,41360	0,42230	0,00870	-11,68		insitu					
		check	45,05			check	4,30725	4,31710	0,00985			check					
	3	insitu	31,75	-1,89		insitu	0,43040	0,44230	0,01190	-2,22		insitu					
		check	31,15		3,75	check	4,32485	4,33702	0,01217		-5,77	check					
14-03	1	insitu	19,33	15,42		insitu	1,94900	1,95300	0,00400	-65,00		insitu					
		check	22,31			check	4,37322	4,38465	0,01143			check					
	2	insitu	22,82	13,50		insitu	1,97500	1,98600	0,01100	-18,70		insitu					
		check	25,90			check	4,39984	4,41337	0,01353			check					
	3	insitu				insitu	1,98500	2,01400	0,02900	120,87		insitu					
		check			14,46	check	4,43142	4,44455	0,01313		12,39	check					
14-04	1	insitu	34,21	4,62		insitu	7,48900	7,50900	0,02000	13,31		insitu					
		check	35,86			check	0,54576	0,56341	0,01765			check					
	2	insitu	48,78	18,98		insitu	7,41500	7,42900	0,01400	-11,17		insitu					
		check	58,04			check	4,49201	4,50777	0,01576			check					
	3	insitu	36,82	7,55		insitu	7,45500	7,47400	0,01900	19,50		insitu					
		check	39,60		10,45	check	0,51541	0,53131	0,01590		7,21	check					
14-05	1	insitu	15,58	2,31		insitu	5,21450	5,23560	0,02110	-2,04		insitu					
		check	15,94			check	4,54734	4,56888	0,02154			check					
	2	insitu	15,62	4,18		insitu	5,25640	5,27420	0,01780	-2,25		insitu					
		check	16,28			check	4,58815	4,60636	0,01821			check					
	3	insitu	16,34	2,69		insitu	5,27730	5,31340	0,03610	-1,93		insitu					
		check	16,78		3,06	check	4,60960	4,64641	0,03681		-2,07	check					
14-06	1	insitu	25,37	67,32		insitu	2,63500	2,64900	0,01400	-1,13		insitu					
		check	42,45			check	0,58620	0,60036	0,01416			check					
	2	insitu	28,53	54,12		insitu	2,70400	2,71500	0,01100	-2,31		insitu					
		check	43,97			check	0,63570	0,64696	0,01126			check					
	3	insitu	29,27	34,81		insitu	2,74500	2,75800	0,01300	0,31		insitu					
		check	39,46		52,09	check	0,66425	0,67721	0,01296		-1,04	check					
14-07	1	insitu	37,31	-2,71		insitu	8,77175	8,78445	0,01270	-4,87		insitu					
		check	36,30			check	0,69470	0,70805	0,01335			check					
	2	insitu	39,84	-0,03		insitu	8,79265	8,80035	0,00770	-4,47		insitu					
		check	39,83			check	0,71600	0,72406	0,00806			check					
	3	insitu				insitu	8,80365	8,81095	0,00730	-4,20		insitu					
		check	48,60		-1,37	check	0,72746	0,73508	0,00762		-4,51	check					
14-08	1	insitu	53,83	1,84		insitu	6,44500	6,44900	0,00400	-40,30		insitu	6,47800	6,50500	0,02700	6,85	
		check	54,82			check	0,75186	0,75856	0,00670			check	0,78689	0,81216	0,02527		
	2	insitu				insitu	6,46400	6,47500	0,01100	3,58		insitu	6,52800	6,55500	0,02700	9,71	
		check				check	0,77270	0,78332	0,01062			check	0,83842	0,86303	0,02461		
	3	insitu				insitu	0,51500	0,52600	0,01100	-7,87		insitu					
		check			1,84	check	0,82357	0,83551	0,01194		-14,86	check					8,28

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DURBAN CORPORATION - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
				Error	Average		Reading		Diff	Error	Average		Reading		Diff	Error	Average
			l/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
14-09	1	insitu	32,45	32,05		insitu	0,83780	0,85350	0,01570	3,45		insitu					
		check	42,85			check	0,90009	0,91526	0,01517			check					
	2	insitu	46,97	1,30		insitu	0,86980	0,88070	0,01090	1,87		insitu					
		check	47,58			check	0,93106	0,94176	0,01070			check					
	3	insitu	36,63	19,16		insitu	0,89550	0,90550	0,01000	3,73		insitu					
		check	43,65		17,50	check	0,95496	0,96460	0,00964		3,03	check					
14-10	1	insitu	34,15	71,19		insitu	8,95450	8,96480	0,01030	11,83		insitu	8,92550	8,95180	0,02630	4,53	
		check	58,46			check	1,03206	1,04127	0,00921			check	1,00440	1,02956	0,02516		
	2	insitu	32,31	73,57		insitu	9,00650	9,01880	0,01230	9,14		insitu	8,98050	9,00050	0,02000	4,06	
		check	56,08			check	1,07270	1,08397	0,01127			check	1,04905	1,06816	0,01911		
	3	insitu	34,37	72,56		insitu						insitu					
		check	59,31		72,44	check					10,49	check					4,59
14-11	1	insitu	56,30	11,24		insitu	6,98700	7,00800	0,02100	32,16		insitu	6,96400	6,98500	0,02100	-20,45	
		check	62,63			check	1,13808	1,15397	0,01589			check	1,11168	1,13808	0,02640		
	2	insitu				insitu	7,03600	7,05200	0,01600	5,96		insitu	7,00800	7,03600	0,02800	-3,88	
		check				check	1,18310	1,19820	0,01510			check	1,15397	1,18310	0,02913		
	3	insitu				insitu	7,07500	7,08600	0,01100	3,77		insitu	7,05200	7,07500	0,02300	-2,83	
		check			11,24	check	1,22187	1,23247	0,01060		13,96	check	1,19820	1,22187	0,02367		-9,0
14-12	1	insitu	50,17	-2,91		insitu	7,34660	7,35440	0,00780	-2,99		insitu	7,32690	7,34660	0,01970	-3,24	
		check	48,71			check	1,28450	1,29254	0,00804			check	1,26414	1,28450	0,02036		
	2	insitu				insitu	7,38130	7,39170	0,01040	-4,15		insitu	7,35440	7,38130	0,02690	-2,39	
		check				check	1,32010	1,33095	0,01085			check	1,29254	1,32010	0,02756		
	3	insitu				insitu						insitu					
		check			-2,91	check					-3,57	check					-2,8
15-01	1	insitu	20,22	-7,37		insitu	0,45470	0,47440	0,01970	-4,51		insitu					
		check	18,73			check	4,69987	4,72050	0,02063			check					
	2	insitu	17,56	0,17		insitu	0,49130	0,50670	0,01540	-3,63		insitu					
		check	17,59			check	4,73813	4,75411	0,01598			check					
	3	insitu				insitu	0,50920	0,52110	0,01190	-4,26		insitu					
		check			-3,60	check	4,75683	4,76926	0,01243		-4,13	check					
15-02	1	insitu	46,04	4,69		insitu	2,72800	2,73700	0,00900	5,14		insitu	2,71500	2,72800	0,01300	-8,96	
		check	48,20			check	4,79916	4,80772	0,00856			check	4,78488	4,79916	0,01428		
	2	insitu				insitu	2,75400	2,76400	0,01000	3,52		insitu	2,73700	2,75400	0,01700	-0,70	
		check				check	4,82484	4,83450	0,00966			check	4,80772	4,82484	0,01712		
	3	insitu				insitu						insitu					
		check			4,69	check					4,33	check					-4,8
15-03	1	insitu	16,60	51,51		insitu	1,93130	1,95460	0,02330	15,63		insitu					
		check	25,15			check	4,89991	4,92006	0,02015			check					
	2	insitu	20,60	55,63		insitu	1,95460	1,97430	0,01970	2,28		insitu					
		check	32,06			check	4,92006	4,93932	0,01926			check					
	3	insitu	19,78	63,45		insitu	2,01850	2,03950	0,02100	11,17		insitu					
		check	32,33		56,86	check	4,95861	4,97750	0,01889		9,70	check					
15-04	1	insitu	36,72	3,95		insitu	3,88150	3,91380	0,03230	2,41		insitu	3,91380	3,94500	0,03120	-3,73	
		check	38,17			check	5,00794	5,03948	0,03154			check	5,03948	5,07189	0,03241		
	2	insitu	28,66	6,59		insitu	3,98500	4,01470	0,02970	4,03		insitu	3,95370	3,98500	0,03130	-3,75	
		check	30,55			check	5,11177	5,14032	0,02855			check	5,07925	5,11177	0,03252		
	3	insitu	28,56	4,87		insitu						insitu					
		check	29,95		5,14	check					3,22	check					-3,74

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DURBAN CORPORATION - INSITU METER TESTING

Slow

Test No.	Run No.		l/l	Error %	Average
15-05	1	insitu	43.30	0.81	
		check	43.65		
	2	insitu			
		check			
	3	insitu			
		check			0.81
15-06	1	insitu	30.77	10.53	
		check	34.01		
	2	insitu	33.57	13.26	
		check	38.02		
	3	insitu			
		check			11.89
15-07	1	insitu	52.75	16.21	
		check	61.30		
	2	insitu	46.93	3.17	
		check	48.42		
	3	insitu	44.97	5.45	
		check	47.42		8.28
15-08	1	insitu	22.31	7.71	
		check	24.03		
	2	insitu			
		check			
	3	insitu			
		check			7.71
15-09	1	insitu	28.96	4.97	
		check	30.40		
	2	insitu	23.00	19.13	
		check	27.40		
	3	insitu			
		check			12.05
15-10	1	insitu	58.15	4.63	
		check	60.84		
	2	insitu	52.27	4.63	
		check	54.69		
	3	insitu			
		check			4.63
15-11	1	insitu	53.59	2.20	
		check	54.77		
	2	insitu	51.06	0.27	
		check	51.20		
	3	insitu	47.72	10.50	
		check	52.73		4.32
15-12	1	insitu	49.20	2.72	
		check	50.54		
	2	insitu	41.96	9.32	
		check	45.87		
	3	insitu			
		check			6.02

Medium

Test No.	Run No.		Reading Initial	Final	Diff kl	Error %	Average
15-05	1	insitu	1.38000	1.40600	0.02600	61.79	
		check	5.18181	5.19788	0.01607		
	2	insitu	1.42500	1.45000	0.02500	60.05	
		check	5.21824	5.23386	0.01562		
	3	insitu	1.48400	1.50300	0.01900	2.76	
		check	5.28552	5.30401	0.01849		41.53
15-06	1	insitu	3.33750	3.35450	0.01700	-0.35	
		check	5.34130	5.35836	0.01706		
	2	insitu	3.38040	3.39850	0.01810	2.03	
		check	5.38500	5.40274	0.01774		
	3	insitu					
		check					0.84
15-07	1	insitu	0.04700	0.05620	0.00920	0.11	
		check	5.46089	5.47008	0.00919		
	2	insitu	0.09240	0.10120	0.00880	2.09	
		check	5.50658	5.51520	0.00862		
	3	insitu					
		check					1.10
15-08	1	insitu	0.97200	0.98300	0.01100	1.29	
		check	5.55960	5.57046	0.01086		
	2	insitu	1.00800	1.02200	0.01400	1.01	
		check	5.59485	5.60871	0.01386		
	3	insitu					
		check					1.15
15-09	1	insitu	3.03600	3.05600	0.02000	-7.06	
		check	5.64142	5.66294	0.02152		
	2	insitu	3.09600	3.10800	0.01200	2.74	
		check	5.70472	5.71640	0.01168		
	3	insitu					
		check					-2.16
15-10	1	insitu	6.90480	6.91370	0.00890	0.00	
		check	5.75111	5.76001	0.00890		
	2	insitu	6.94140	6.95090	0.00950	0.21	
		check	5.78766	5.79714	0.00948		
	3	insitu					
		check					0.11
15-11	1	insitu	0.32250	0.32965	0.00715	-0.56	
		check	5.83701	5.84420	0.00719		
	2	insitu	0.36039	0.37429	0.01390	-0.86	
		check	5.87450	5.88852	0.01402		
	3	insitu					
		check					-0.71
15-12	1	insitu	8.47100	8.48100	0.01000	2.99	
		check	5.93129	5.94100	0.00971		
	2	insitu	8.54400	8.55800	0.01400	1.38	
		check	6.00254	6.01635	0.01381		
	3	insitu					
		check					2.18

Fast

Test No.	Run No.		Reading Initial	Final	Diff kl	Error %	Average
15-05	1	insitu	1.36400	1.38000	0.01600	-40.10	
		check	5.15510	5.18181	0.02671		
	2	insitu	1.40600	1.42500	0.01900	-6.68	
		check	5.19788	5.21824	0.02036		
	3	insitu	1.45000	1.48400	0.03400	-3.02	
		check	5.25046	5.28552	0.03506		-16.6[illegible]
15-06	1	insitu	3.31690	3.33750	0.02060	-2.00	
		check	5.32028	5.34130	0.02102		
	2	insitu	3.35450	3.38040	0.02590	-2.78	
		check	5.35836	5.38500	0.02664		
	3	insitu					
		check					-2.3[illegible]
15-07	1	insitu	0.02240	0.04700	0.02460	-0.57	
		check	5.43615	5.46089	0.02474		
	2	insitu	0.05620	0.09240	0.03620	-0.82	
		check	5.47008	5.50658	0.03650		
	3	insitu					
		check					-0.6[illegible]
15-08	1	insitu	0.96000	0.97200	0.01200	-4.53	
		check	5.54703	5.55960	0.01257		
	2	insitu	0.98300	1.00800	0.02500	2.50	
		check	5.57046	5.59485	0.02439		
	3	insitu					
		check					-1.02
15-09	1	insitu	3.02700	3.03600	0.00900	-7.22	
		check	5.63172	5.64142	0.00970		
	2	insitu	3.07600	3.09600	0.02000	-5.35	
		check	5.68359	5.70472	0.02113		
	3	insitu					
		check					6.2[illegible]
15-10	1	insitu	6.88560	6.90480	0.01920	-0.36	
		check	5.73184	5.75111	0.01927		
	2	insitu	6.91370	6.94140	0.02770	0.18	
		check	5.76001	5.78766	0.02765		
	3	insitu					
		check					-0.0[illegible]
15-11	1	insitu	0.31023	0.32250	0.01227	0.08	
		check	5.82475	5.83701	0.01226		
	2	insitu	0.34465	0.36039	0.01574	1.35	
		check	5.85897	5.87450	0.01553		
	3	insitu					
		check					0.72
15-12	1	insitu	8.45100	8.47100	0.02000	2.72	
		check	5.91182	5.93129	0.01947		
	2	insitu	8.48100	8.50600	0.02500	-4.54	
		check	5.94100	5.96719	0.02619		
	3	insitu					
		check					-0.9[illegible]

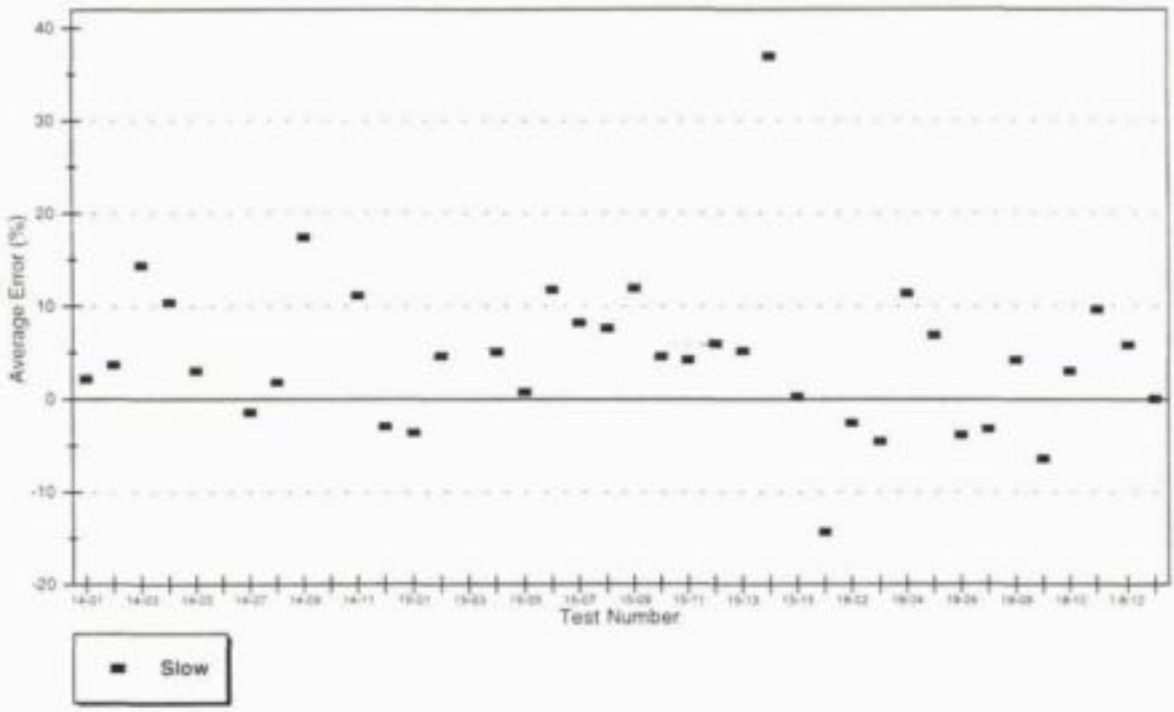
DURBAN CORPORATION - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
				Error	Average		Reading		Diff	Error	Average		Reading		Diff	Error	Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
15-13	1	insitu	27.50	6.80		insitu	8.65800	8.66970	0.01170	-0.17		insitu	8.63150	8.65800	0.02650	-1.30	
		check	29.37			check	6.12022	6.13194	0.01172			check	6.09337	6.12022	0.02685		
	2	insitu	27.43	3.72		insitu	8.70000	8.71570	0.01570	-1.32		insitu	8.67580	8.70000	0.02420	-0.58	
		check	28.45			check	6.16120	6.17711	0.01591			check	6.13686	6.16120	0.02434		
	3	insitu				insitu						insitu					
		check			5.26	check					-0.75	check					-0.94
15-14	1	insitu	40.34	36.99		insitu	1.98290	1.99240	0.00950	8.45		insitu	1.95760	1.98290	0.02530	3.77	
		check	55.26			check	6.21588	6.22464	0.00876			check	6.19150	6.21588	0.02438		
	2	insitu				insitu	2.01340	2.02270	0.00930	5.56		insitu	1.99240	2.01340	0.02100	0.19	
		check				check	6.24560	6.25441	0.00881			check	6.22464	6.24560	0.02096		
	3	insitu				insitu						insitu					
		check			36.99	check					7.00	check					1.96
15-15	1	insitu	52.07	0.33		insitu	4.23600	4.24440	0.00840	3.96		insitu	4.22340	4.23600	0.01260	-1.18	
		check	52.24			check	6.29987	6.30795	0.00808			check	6.28712	6.29987	0.01275		
	2	insitu				insitu	4.26300	4.27400	0.01100	0.46		insitu	4.24440	4.26300	0.01860	0.49	
		check				check	6.32646	6.33741	0.01095			check	6.30795	6.32646	0.01851		
	3	insitu				insitu						insitu					
		check			0.33	check					2.21	check					-0.31
18-01	1	insitu	39.00	-14.10		insitu	4516.10000	4516.11200	0.01200	-22.03		insitu	4516.13400	4516.15600	0.02200	46.57	
		check	33.50			check	1.39706	1.41245	0.01539			check	1.43597	1.45098	0.01501		
	2	insitu	38.80	-14.43		insitu	4516.11200	4516.12300	0.01100	-11.43		insitu	4516.15600	4516.17000	0.01400	-22.44	
		check	33.20			check	1.41245	1.42487	0.01242			check	1.45098	1.46903	0.01805		
	3	insitu				insitu	4516.12300	4516.13400	0.01100	-0.90		insitu	4516.17000	4516.18700	0.01700	14.63	
		check			-14.27	check	1.42487	1.43597	0.01110		-1145	check	1.46903	1.48386	0.01483		12.92
18-02	1	insitu	28.60	-4.55		insitu	5362.73100	5362.74400	0.01300	10.92		insitu	5362.75300	5362.77200	0.01900	2.81	
		check	27.30			check	1.52819	1.53991	0.01172			check	1.54962	1.56810	0.01848		
	2	insitu	25.80	-0.39		insitu	5362.74400	5362.75300	0.00900	-7.31		insitu	5362.77000	5362.79300	0.02300	10.36	
		check	25.70			check	1.53991	1.54962	0.00971			check	1.56810	1.58894	0.02084		
	3	insitu				insitu						insitu					
		check			-2.47	check					1.80	check					6.51
18-03	1	insitu	21.50	-3.26		insitu	7585.32300	7585.34000	0.01700	-4.01		insitu	7585.35300	7585.38500	0.03200	0.57	
		check	20.80			check	1.64178	1.65949	0.01771			check	1.67266	1.70448	0.03182		
	2	insitu	20.90	-5.74		insitu	7585.34000	7585.35300	0.01300	-1.29		insitu	7585.38500	7585.40600	0.02100	-3.71	
		check	19.70			check	1.65949	1.67266	0.01317			check	1.70448	1.72629	0.02181		
	3	insitu				insitu						insitu					
		check			-4.50	check					-2.65	check					-1.57
18-04	1	insitu	29.00	7.59		insitu	6072.44500	6072.47000	0.02500	-1.15		insitu	6072.49100	6072.52800	0.03700	-1.46	
		check	31.20			check	1.76721	1.79250	0.02529			check	1.81334	1.85089	0.03755		
	2	insitu	29.30	15.36		insitu	6072.47000	6072.49100	0.02100	0.77		insitu	6072.52800	6072.55700	0.02900	2.18	
		check	33.80			check	1.79250	1.81334	0.02084			check	1.85089	1.87927	0.02838		
	3	insitu				insitu						insitu	6072.55700	6072.57900	0.02200	-6.14	
		check			11.47	check					-0.19	check	1.87927	1.90271	0.02344		-1.81
18-05	1	insitu	37.00	5.41		insitu	26.18547	26.20335	0.01788	1.36		insitu	26.22018	26.25423	0.03405	2.87	
		check	39.00			check	1.94137	1.95901	0.01764			check	1.97621	2.00931	0.03310		
	2	insitu	35.00	8.57		insitu	26.20335	26.22018	0.01683	-2.15		insitu	26.25423	26.27944	0.02521	0.76	
		check	38.00			check	1.95901	1.97621	0.01720			check	2.00931	2.03433	0.02502		
	3	insitu				insitu						insitu					
		check			6.99	check					-0.43	check					1.81

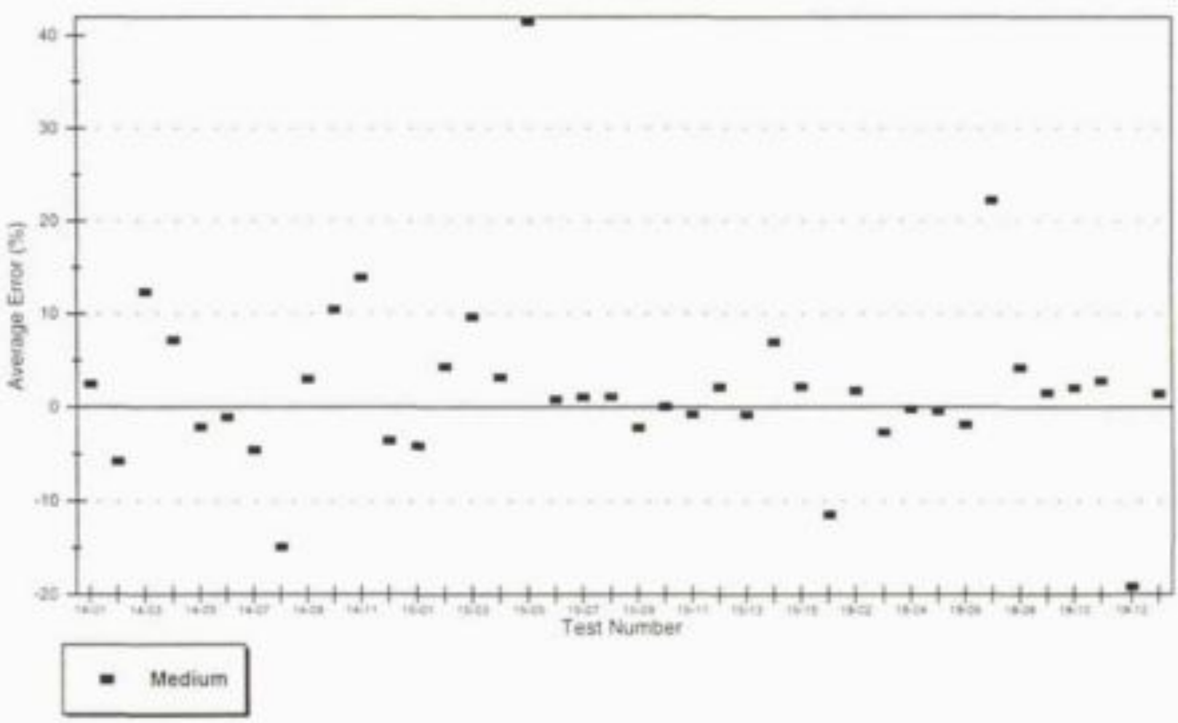
DURBAN CORPORATION - INSITU METER TESTING

Test No.	Run No.	Slow				Medium						Fast					
				Error	Average		Reading		Diff	Error	Average		Reading		Diff	Error	Average
			s/l	%			Initial	Final	kl	%			Initial	Final	kl	%	
18-06	1	insitu	66,00	-7,58		insitu	9,54365	9,55287	0,00922	-1,71		insitu	9,58152	9,59210	0,01058	-41,35	
		check	61,00			check	2,05556	2,06494	0,00938			check	2,09366	2,11170	0,01804		
	2	insitu	57,00	0,00		insitu	9,55287	9,56370	0,01083	-1,99		insitu	9,59921	9,61270	0,01349	-2,10	
		check	57,00			check	2,06494	2,07599	0,01105			check	2,11170	2,12548	0,01378		
	3	insitu				insitu						insitu					
		check			-3,79	check					-1,85	check					-21,73
18-07	1	insitu	33,00	0,00		insitu	59,77730	59,78530	0,00800	11,42		insitu	59,79390	59,81170	0,01780	2,18	
		check	33,00			check	2,14246	2,14964	0,00718			check	2,15609	2,17351	0,01742		
	2	insitu	32,00	-6,25		insitu	59,78530	59,79390	0,00860	33,13		insitu	59,81170	59,83400	0,02230	1,50	
		check	30,00			check	2,14963	2,15609	0,00646			check	2,17351	2,19548	0,02197		
	3	insitu				insitu						insitu					
		check			-3,13	check					22,27	check					1,84
18-08	1	insitu	37,00	2,70		insitu	347,19520	347,20350	0,00830	3,23		insitu	347,21060	347,24040	0,02980	2,16	
		check	38,00			check	2,23072	2,23876	0,00804			check	2,24550	2,27467	0,02917		
	2	insitu	34,00	5,88		insitu	347,20350	347,21060	0,00710	5,34		insitu	347,24040	347,26800	0,02760	2,30	
		check	36,00			check	2,23876	2,24550	0,00674			check	2,27467	2,30165	0,02698		
	3	insitu				insitu						insitu					
		check			4,29	check					4,29	check					2,23
18-09	1	insitu	33,00	-6,06		insitu	10,68970	10,69648	0,00678	1,50		insitu	10,70334	10,72228	0,01894	12,20	
		check	31,00			check	2,33121	2,33789	0,00668			check	2,34464	2,36152	0,01688		
	2	insitu	30,00	-6,67		insitu	10,69648	10,70334	0,00686	1,63		insitu	10,72228	10,73989	0,01761	2,03	
		check	28,00			check	2,33789	2,34464	0,00675			check	2,36152	2,37878	0,01726		
	3	insitu				insitu						insitu					
		check			-6,36	check					1,56	check					7,12
18-10	1	insitu	33,00	3,03		insitu	49,91000	49,92080	0,01080	2,18		insitu	49,92980	49,94900	0,01920	-2,29	
		check	34,00			check	2,41059	2,42116	0,01057			check	2,42998	2,44963	0,01965		
	2	insitu	32,00	3,13		insitu	49,92080	49,92980	0,00900	2,04		insitu	49,94900	49,96860	0,01960	-0,96	
		check	33,00			check	2,42116	2,42998	0,00882			check	2,44963	2,46942	0,01979		
	3	insitu				insitu						insitu					
		check			3,08	check					2,11	check					-1,63
18-11	1	insitu	30,00	13,33		insitu	59,56140	59,56980	0,00840	10,09		insitu	59,58450	59,60300	0,01850	1,59	
		check	34,00			check	2,48986	2,49749	0,00763			check	2,51231	2,53052	0,01821		
	2	insitu	33,00	3,03		insitu	59,56980	59,57740	0,00760	-0,91		insitu	59,60300	59,62350	0,02050	0,10	
		check	34,00			check	2,49749	2,50516	0,00767			check	2,53052	2,55100	0,02048		
	3	insitu	33,00	3,03		insitu	59,57740	59,58450	0,00710	-0,70		insitu					
		check	34,00		9,70	check	2,50516	2,51231	0,00715		2,83	check					0,8[illegible]
18-12	1	insitu	29,40	3,06		insitu	6692,70400	6692,70900	0,00500	-21,01		insitu	6692,71500	6692,73600	0,02100	-5,83	
		check	30,30			check	2,58670	2,59303	0,00633			check	2,60028	2,62258	0,02230		
	2	insitu	25,10	8,76		insitu	6692,70900	6692,71500	0,00600	-17,24		insitu	6692,73600	6692,75600	0,02000	0,10	
		check	27,30			check	2,59303	2,60028	0,00725			check	2,62258	2,64256	0,01998		
	3	insitu				insitu						insitu					
		check			5,91	check					-19,13	check					-2,8[illegible]
18-13	1	insitu				insitu	19,90812	19,91845	0,01033	1,77		insitu	19,92680	19,95368	0,02688	1,40	
		check				check	2,69525	2,70540	0,01015			check	2,71366	2,74017	0,02651		
	2	insitu	33,00	-3,03		insitu	19,91845	19,92680	0,00835	1,09		insitu	19,95368	19,97446	0,02078	0,97	
		check	32,00			check	2,70540	2,71366	0,00826			check	2,74017	2,76075	0,02058		
	3	insitu	31,00	3,23		insitu						insitu					
		check	32,00		0,10	check					1,43	check					1,1[illegible]

Errors Scatter Graph



Errors Scatter Graph



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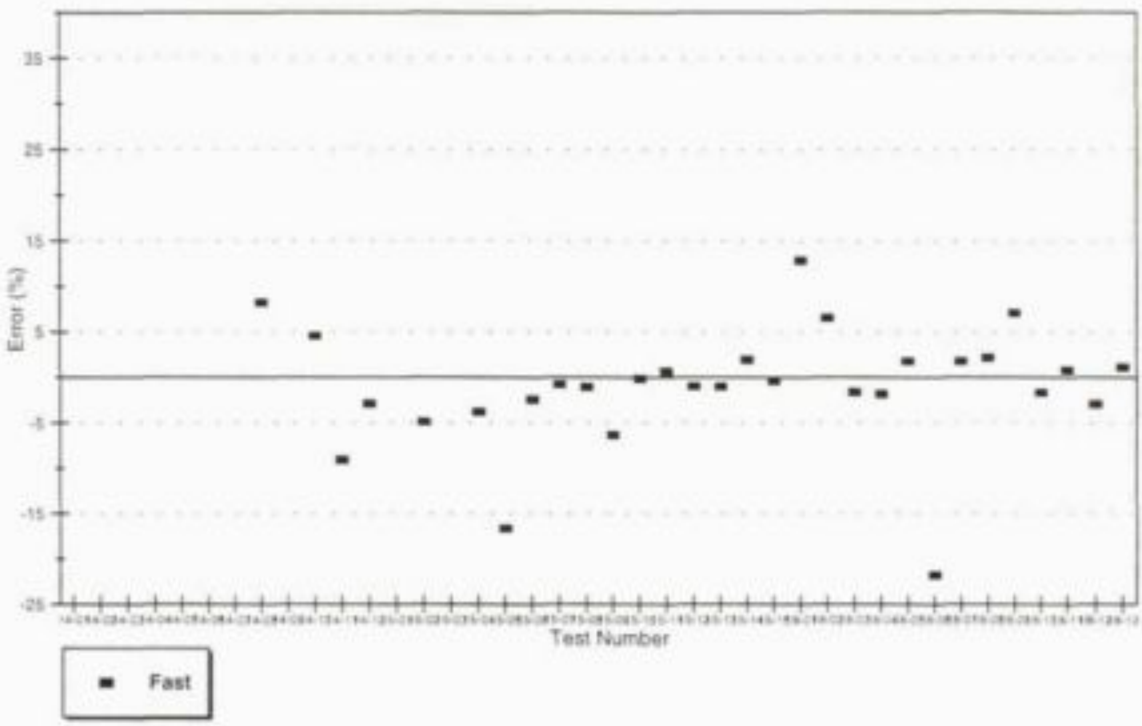

IN-SITU METER TESTS OF LARGE CONSUMERS IN KEMPTON PARK

DATE : January 1994 - June 1995

OPSOMMING VAN METERTOETSE

Nr	Firma	Rekening nommer	Erf nr	Adres	Metertipe	Grootte	Gal of kl	Meternom	Afwyking van Standaard in %(+=vinnig -= stadig)			Opmerkings
									Gem Stadig Toets	Gem Med Toets	Gem Vinnige Toets	
1	C & L Express		222	Qualityweg Isando	Master	40mm	kl		Nie Gedoen	-2,67	3,60	
2	Isando Timbers			Qualitystraat	Master	80mm	kl	62470	Nie Gedoen	64,35	58,60	
3	Epic Oils		616	Qualityweg	Master	100mm	kl		Nie Gedoen	1,10	-4,04	
4	Epic Oils		615	Furnaceweg	Master	100mm	kl	43049	Nie Gedoen	-4,99	-0,75	
5	E Snell & Co		161	Dieselweg	Master	80mm	kl	35792	-53,39	-50,20	-51,38	Meter Vervang
6	Kohler Tubes			Dieselweg 40 Isando	Master	50mm	kl	221	3,02	2,72	1,36	
7	Bakke		216	Dieselweg	Master	40mm	kl	33534	3,31	-0,22	-0,44	
8	Flender & Premier Freight		214	Furnacelaan	Master	50mm	kl	48260	Nie Gedoen	-19,80	-19,67	
9	WBD		358	Industrieweg 15	Master	40mm	kl	48090	0,53	3,67	1,03	
10	Custom Plastics		461	Dieselweg	Master	80mm	kl	21207	2,44	7,12	7,64	
11	Amcor		610	Anvilweg	Master	50mm	kl	21026	0,67	7,08	Nie Gedoen	
12	Veltsak		609	H/v Industry en Isandoweg	Master	50mm	kl	41277	1,40	0,25	0,77	
13	Veltsak		434	Industryweg 8	Master	40mm	kl	41027	Nie Gedoen	-0,68	-1,41	Voldoen nie aan verbruikspatroon
14	Bayers		400	Wrenchweg 27	Helix	100mm	kl	56338	-11,94	-2,20	2,71	
15	Caterpillar		427	Anvilweg 54	Helix	100mm	kl		-38,12	42,41	1,44	Meter moet vervang word Onakkuraat
17	Fattis & Monis		565	Dieselweg	Master	50mm	kl	38384	Nie Gedoen	12,79	11,87	Meter is vervang
18	XPS		476	Wrenchweg	Master	40mm	kl	41043	0,45	-0,06	-0,92	
19	Firestone		186	Qualityweg	Master	40mm	kl	41029	0,70	-0,80	-0,51	
20	Firestone		186	Qualityweg	Master	40mm	kl	60516	1,62	0,67	-0,72	Huishoudelike meter
21	Koppel Elga		511	Breweryweg	Master	40mm	kl	67054	0,27	-0,93	-1,18	
22	Malcomes		438	Monteerweg 32	Master	50mm	kl	29817	-44,28	-99,62	-99,29	Meter is vervang
23	All Auto Fix			Powerstraat 14		40mm	kl	82813	0,83	-0,78	-1,57	
24	Engen	Sien nr 34		Breweryweg	Master	50mm	kl	61634	4,00	1,86	5,13	
25	Exactum			Breweryweg 12	Master	50mm	kl	73954	5,43	2,57	-1,67	
26	Dunlop Flooring		125	Breweryweg	Master	40mm	kl	50471	Nie Gedoen	0,12	-0,19	
27	EmmEss			Breweryweg	Master	50mm	kl		1,37	1,15	0,73	
28	Kuenne & Nagel		87	Lithestraat	Master	50mm	kl	39470	2,36	3,39	0,73	
29	Komdresco		468	Isandoweg	Master	40mm	kl	48060	Nie Gedoen	0,64	1,53	
30	S A Die & Pattern		90	Powerstraat	Master	50mm	kl	20787	-4,06	-1,47	-1,87	
31	Hellmann		325	Electronweg	Master	40mm	kl	16329	0,63	-0,07	-0,85	
32	S A Brewery		124	Breweryweg 124	Master	40mm	kl		0,09	2,37	-1,35	
33	Isando Nywerhede		434	Industrieweg	Master	50mm	kl	64642	2,62	2,03	-0,26	
34	Engen	Sien nr 24		Brewery	Master	50mm	kl	24994	8,65	1,75	1,77	
35	Bazart & Diamant		403	Wrenchweg 4	Master	80mm	kl	79595	0,20	-0,22	-0,58	
36	Bass Engineering			Derrickweg 4	Master	40mm	kl		0,76	0,38	0,11	
37	TAL			Riggerweg 53	Master	80mm	kl	99780	1,33	1,47	1,04	
38	Backer's Glass		61	Foundryweg Isando	"??	50mm	kl		Nie Gedoen	-64,79	Nie Gedoen	
39	Rio Bambo	102574507		Weststraat	Castle	25mm	kl	94/0371187	-1,87	-1,88	-2,09	
40	Mill Burrow 1		429	Purlinstraat Isando		100mm	kl	43607	1,65	1,27	1,23	
41	Mill Burrow 2		429	Purlinstraat Isando		80mm	kl	430607	4,59	2,07	1,98	
42	Southern Denver		269	Riggerweg Isando	Master	50mm	kl	86410	2,33	1,49	0,79	

OPSOMMING VAN METERTOETSE

Nr	Firma	Rekening nommer	Erf nr	Adres	Metertipe	Groote	Gal of kl	Meternom	Afwyking van Standaard in %(+=vinnig -= stadig)			Opmerkings
									Gem Stadig Toets	Gem Med Toets	Gem Vinnige Toets	
43	Micor			Andre Greyvenstey Isando	Master	50mm	kl	38476	2,72	2,17	2,03	
44	S A Mining			Derrickweg Isando	Master	50mm	kl	47215	2,03	2,57	1,94	
45	Cordial Foods 1		84	Lathestraat Isando	Master	50mm	kl	20775	Nie Gedoen	2,80	2,25	
46	Cordial Foods 2		84	Lathestraat Isando	Master	50mm	kl	20775	2,79	2,40	2,24	
47	Rebuff		11	Purlinstraat 11 Isando		50mm	kl		3,83	2,08	1,80	
48	Rapid Pump			Graderweg 10 Isando		40mm	kl		0,96	-0,78	-1,19	
49	Colas			Dieselweg Isando	Kent ?	50mm	kl		1,55	-4,57	-5,72	
50	Siemens			Electronweg Isando	Kent ?	40mm	kl	25070	-3,09	7,02	1,22	
51	Ryman			Isandoweg Isando	"??	"??			8,29			
52	International				"??	80mm	kl		0,40	0,30		
53	Acromed		641	Isando	"??	75mm	kl	61144	0,00	0,55	0,79	
54	Acromed		641	Isando	"??	75 ?	kl	61144?	-6,48			
55	Amcor		130	Anvilweg Isando	Master	50mm	kl	21026	0,68	7,76		
56	Caterpillar		427	Anvilstraat Isando	Helix	100mm	kl		Nie Gedoen	Nie Gedoen		
57	Bakers		K227	Qualityweg 43 Isando	Master	50mm	G/kl	67757	Nie Gedoen	1,31		Gallonmeter met kl kop
58	Distrikmeter PLANEWEG			Planeweg Spartan			kl		-9,60	Nie Gedoen		
59	Distrikmeter Npark RES UIT			Norkem Park reservoir			kl		16,03			
60	Distrikmeter PARKLANDO			Parklandrylaan			kl		-10,39			
61	Distrikmeter MARAUDER			Rhodesfield			kl		3,25			