FINAL PROJECT REPORT

TO THE

WATER RESEARCH COMMISSION

WATKO Building

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Rietfontein

PRETORIA

FLOW RATE AND PATTERNS OF WATER CONSUMPTION AND UNACCOUNTED-FOR WATER LOSSES IN URBAN AREAS

UNIVERSITY OF PRETORIA

DEPARTMENT OF CIVIL ENGINEERING

PRETORIA

0001

PROF D HOPKINS PROF P SAVAGE MR E FOX

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The following persons were, from time to time, associated with the steering committee responsible for the project:

Mr H C Chapman	Water Research Commission
Mr D Moore	Division of Building Technology
Mr P H S Cronje	Pretoria City Council
Mr A Smook	Pretoria City Council
Mr T Westman	Pretoria City Council
Mr Z A Coetzee	Pretoria City Council
Mr D S vd Merwe	Water Research Commission
Mr F P Marais	Water Research Commission
Prof A W Rohde	University of Pretoria
Prof D Hopkins	University of Pretoria
Prof P Savage	University of Pretoria
Mr E Fox	University of Pretoria
Mr D Gebhardt	University of Pretoria
Mr T Leonie	Water Management Services
Mr R P Donovan	JASWIC

The authors wish to thank all of the above who have been associated with the project as without their guidance and contributions results would not have been achieved.

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Mr B Bold and Mr D van Eden of Liquid Meters for their assistance with the calibration of the bulk meters used during the project.

The staff of the Pretoria City Engineer's Department for their help and support.

The results of this research, although incomplete, will be of benefit to all three of the participating organisations, albeit for different reasons.

AIMS OF THE PROJECT

* To establish actual consumption rates and patterns for domestic and industrial consumers under varying conditions such as locality, pressure, draw-off and personality of water.

* To determine the most appropriate size and capacity of water meters.

* To remove and test meter samples at the actual "low", "medium" and "high" flow rates in accordance with results above.

* To retest these meters at the corresponding flow rates prescribed by Metrology Act for comparative purposes.

* To recommend consequential meter maintenance and replacement programmes.

* To review the relevant sections of the existing Trade Metrology Act in the light of the results obtained.

* To determine the "unaccounted-for" component of water supplied within various consumption zones, with due account of the word done by the Water Research Commission.

FINAL REPORT

Research into The Flow Rate and Patterns of Water Consumption and Unaccounted-for Water Losses in Urban Areas.

INTRODUCTION

1. On 9th October 1987 the University of Pretoria entered into an agreement with the Pretoria City Council and the Water Research Commission to undertake research into the flow rate and patterns of water consumption and unaccounted-for water losses in urban areas.

2. This project was scheduled to commence on 1 June 1987 and to terminate after two years. On 17 April 1989 an application for additional funds and an extension of time of one year was submitted, later supported by a memorandum dated 12 May 1989 outlining the work still to be done until 30 April 1990.

   On 31 October 1989 the Commission granted an additional R45 000-00 and an extension time of 1 year.

3. During the course of this project considerable problems were experienced and these we detailed in our Memorandum dated 17 April 1989. Furthermore, these problems were discussed verbally with your Mr Chapman and Mr van der Merwe, when it was pointed out that suitable isolated areas, except for one were not provided. The matter was also discussed with Mr du Toit, Deputy City Engineer and Mr Smook on 11 April 1990. Because of these problems considerable delay has resulted, and on 29 May 1990 a request for an additional extension of 1

year, until 30 April 1991 was submitted. Your letter dated 6 June stated that this request could not be acceded to and a final report on the activities of the research team was to be submitted by the middle of September 1990, and that the terminal date of this project is 8 October 1990.

4. This report is therefore inconclusive as all the proposed work has not been completed. However, it reflects the research work and findings to date.

5. During the course of this project four Progress Reports were submitted to the various meetings of the Steering Committee. These reports deal with the results obtained from investigating the following areas:

5.1	Magalieskruin	25-06-88	to 7-08-88
5.2	Waterkloof Ridge Ext 2	14-08-88	to 17-09-88
5.3	Valhalla	29-10-88	to 3-11-88
5.4	Capital Park	5-11-88	to 26-11-88
5.5	Faerie Glen	25-03-89	to 29-04-89
5.6	Waterkloof Heights	6-05-89	to 24-06-89
5.7	Faerie Glen	1-07-89	to 5-08-89
5.8	Waterkloof Heights	26-08-89	to 30-09-89
5.9	Koedoespoort	8-11-89	to 16-02-90
5.10	Capital Park	8-03-90	to 7-04-90

5.11 During the period 11 July to 18 July 1989 the Pretoria City Council installed loggers in Valhalla and flow rate patterns were recorded and submitted to this research team.

6. Details of the research proposed to be undertaken and recommendations to be made are embodied in the original "Memorandum: Water Research Commission: Research Project Proposals" dated 15 September 1986.

A paper entitled "Problems encountered during research into flow-rate and patterns of water consumption and

unaccounted for water losses in urban areas", is being submitted for publication.

7. A summary and analysis of the investigations carried out in items 5.1 to 5.10 (inclusive) is as follows:

5.1 Magalieskruin

During this investigation the main supply to the area was discontinued.

TABLE 1

Date	Meter Standard flow kl	Total Outflow kl 271 domestic meters	Percentage under registration	Consumption kl/meter/day
88-06-25	Begin			
88-07-09	4277,6	3868,6	9,5	1,27
88-07-16	2240,3	2240,0	0,0	1,18
88-07-23	2492,2	2308,4	7,3	1,31
88-07-30	2449,3	2293,3	6,4	1,29
88-08-07	3067,7	2963,5	3,4	1,41

During this period it was confirmed by the Council that there had been no leaks, fire-hydrant draw-offs or any other unrecorded draw-offs from the system, and that no other supply point fed the particular area. However, during this test run it was established that a number of meters were indeed fed from a second supply source and consequently the results from this investigation are therefore discarded.

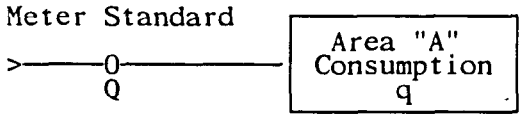
In order to examine individual meter performances, arrangements were made with the Council for the testing of a sample of 50 meters from this area, on the Council's test bed, and for the recalibration of the meter standard by the supplier.

5.2 Waterkloof Ridge Ext No 2

TABLE 2

Date	Meter Standard flow kl	Total Outflow kl 193 domestic meters	Percentage under registration	Consumption kl/meter/day
88-08-14	Begin			
88-02-20	750,4	724,7	3,4	1,33
88-08-27	933,4	895,1	4,2	1,42
88-09-10	1534,2	1503,9	2,0	1,17
88-09-17	890,8	854,2	4,0	1,35

During the test it was established that out of a total of 193 meters, 99 meters were in fact fed from a second source, leaving 94 meters to be tested. Although the experimental consistency of these results is acceptable, the order of magnitude suggests that, once again certain meters could have been fed from an additional source, as the following analysis confirms:



Additional Source q'

Considering values in the order of those determined at Magalieskruin and assuming a q' from an additional unknown source, the following calculation is submitted.

Q = 2240 kl
q = 2230 kl
q' = 300 kl (say)

Disregarding the unknown q' fed into the system the % error is then calculated as:

$$\Delta\% = -\left(\frac{Q - q}{Q}\right) \times 100$$

$$= -\left(\frac{10}{2240}\right) \times 100 = -0{,}45\%$$

Considering the second unknown supply source q' we have:

$$\Delta\% = -\left(\frac{Q - q}{Q + q} + \frac{q'}{Q + q'}\right) \times 100$$

$$= -\left(\frac{10}{2540}\right) + \frac{300}{2540}) + 100$$

$$= -(0{,}004 + 0{,}118) \times 100$$

$$= -12{,}2\%$$

It is therefore clear that a relatively small secondary unknown supply source drastically affects the result to be determined, reflecting a meter which under-registers 12,2% as under-registering only 0,45%.

This highlights the prime importance of a particular area being completely isolated with one supply source only.

Because the very low percentage under-registration reflected in Table 2 is considerably less than that experienced by the outlets elsewhere, the results from this investigation are therefore considered to be unreliable.

In order to examine individual meter performances, arrangements were again made with the Council for the testing of a sample of 20 meters from this area, on the Council's test bed, and for the recalibration of the meter standard by the supplier.

5.3 Valhalla

As a result of the problems experienced in the first two test series the Council undertook to ensure that one supply point only would feed the Valhalla area.

TABLE 3

Date	Meter Standard flow kl	Total Outflow kl	Percentage under registration	Consumption kl/meter/day
88-09-24	Begin			
88-10-01	3829	2826	26,2	1,5
88-10-08	4146	3201	22,8	1,7
88-10-22	5287	3938	25,5	1,0
88-10-29	2242	1575	29,8	0,8

Because of complaints received from local consumers it was decided to carry out the last set of readings, on 88-10-22 without shutting off the main supply. The following readings were recorded during the period the meters were being read.

A total of 40 kl was recorded during the 1½ hour test and the final reading was taken as the initial reading plus half of 40 kl.

Because of the experience at Waterkloof Ridge Ext 2 when it was found that many meters were being fed from an additional source, it was decided to investigate the Valhalla area for leaks, and a series of readings was taken of the bulk meter during the early hours of the mornings. The following was recorded:

TABLE 5

Date	Time	Rate of Flow l/m
88-10-31 88-11-03	02h40/03h13 02h45/03h15	40 40

Since there is only a very small domestic consumption during the early hours of the morning it can be assumed that a very large part of the flow recorded can be ascribed to non-apparent leaks. The flow rate of 40 l/m recorded during a period of minimum flow, will reduce during periods of maximum draw-off. It is therefore assumed that the average leak rate is half of this namely 20 l/m or 202 kl/week, and subtracting this from the meter standard recorded, the following results appear:

TABLE 6

Date	Meter Standard flow kl	Total Outflow	Percentage under registration	Comments
88-09-24	Begin			
88-10-01	3627	2826	22,1	One week
88-10-08	3944	3201	18,8	One week
88-10-22	4883	3938	19,4	Two weeks
88-10-29	2040	1575	22,8	One week

The results from this investigation are considered to be

acceptable and significant.

5.4 Capital Park

The main supply was not cut off.

TABLE 7

Date	Meter Standard flow	Total Outflow kl (171 domestic meters)	Percentage under registration	Consumption kl/meter/day
88-11-05	Begin			
88-11-12	5236	1195	77,2	1,00
88-11-19	5169	1201	76,7	1,00
88-11-26	5239	1348	74,3	1,13
88-12-03	5343	1232	76,9	1,03

Because of the considerable differences between the readings of the Meter Standard and the Individual Meters, the area was investigated for leaks and unregistered consumption. A reading of the Meter Standard was taken at 03h00 on 88-11-17 and it recorded a flow rate of 0,5 1/m, thus indicating that there was no leak out of the system.

An additional meter was placed in series with the Meter Standard and readings of both meters were taken on 88-11-26, as follows:

TABLE 8

Time	08h39	09h09	09h39	10h09	10h27	Difference
Meter Standard	30228	30238	30258	30278	30288	60 kl
Add. Meter	1437	1454	1471	1487	1495	58 kl

The Meter Standard was a combination meter and the additional meter was a simple bulk meter. The variation in the difference over nearly two hours is therefore not significant.

Subsequent to these readings and after it was pointed out to the Council on several occasions, an additional outflow, via a pipe connected back to a lower lever reservoir was discovered. These

results are therefore quite out of proportion, and have been discarded.

5.5 Faerie Glen

Table 9 shows the readings of the Meter Standard during the tests The average was used in order to obtain the flow in Table 10. The main supply was not shut off.

TABLE 9

89-03-25 Meter reading	09H12 74124	10H12 74145	Average 74134
89-04-01 Meter reading	09h12 76945	11h12 77008	 76976
89-04-08 Meter reading	09h10 80060	10h10 80080	 80070
89-04-15 Meter reading	09h11 83409	09h57 83431	 83420
89-04-22 Meter reading	09h10 85745	10h10 85757	 87750
89-04-29 Meter reading	09h00 87669	10h00 87690	 87679

TABLE 10

Date	Meter Standard Flow kl	Total Outflow kl	Percentage under registration	Consumption kl/meter/day
89-03-25	Begin			
89-04-01	2842	2177	23,4	2,27
88-04-08	3094	2720	12,1	2,39
89-04-15	3350	2685	19,9	2,60
89-04-22	2330	2020	13,4	1,81
89-04-29	1929	1356	29,7	1,50

A reading of the Meter Standard was taken between 01h00 and 02hoo on April 7, showing a flow of 4 kl/hour. Assuming, as in the case of Valhalla that the average leak is half of this, namely 2 kl/hour, the weekly loss is 336 kl. Applying this to Table 10 above we get:

TABLE 11

Date	Meter Standard corrected kl	Total Outflow kl	Percentage under registration	Consumption kl/meter/day
89-03-25	Begin			
89-04-01	2506	2177	13,1	1,95
89-04-08	2758	2720	1,4	2,14
89-04-15	3014	2685	10,9	1,52
89-04-22	1994	2020	?	1,55
89-04-29	1539	1356	15,1	1,24

The figures for 89-04-22 suggest that this leak of 336 kl/week did not necessarily take place prior to 89-04-22. It was decided that, for the next area to be investigated, the Council will read the Meter Standard early on the Thursday morning every week before the Saturday readings, in order to establish any possible leaks in the system.

Subsequent to this investigation, the Council reported that a leak had been found on a 20 mm ϕ pipe. The elbow at a joint had come loose and although the Council could not state the rate of flow, it is estimated that, at a head of 40 m the flow through an open-ended 20 mm ϕ pipe would be in the order of 950 kl/week.

5.6 Waterkloof Heights

The area chosen originally consisted of 194 houses but subsequently it was found that the position for the Meter Standard had to be changed due to the watermain being very deep, and consequently 29 houses had to be excluded. Once again readings were taken without closing off the main supply, and the following Tables 12, 13 and 14 record the results obtained. It was noted that the by-pass meter was not recording so that only the Bulk Meter was read. Subsequent readings suggest that the Bulk Meter did not record Low flows, such as night leaks.

TABLE 12

Date	Time	Time	Time	Time	Average Flow Rate	Average Meter Reading
89-05-06	09h30	11h15	-	-		
Meter Reading	107689	107723	-	-	19 l/h	107706
89-05-13	09h50	11h00	-	-		
Meter Reading	111020	111087	-	-	50 l/h	111054

Note "A" During this period the water main kicked out downstream of the Meter Standard. The difference between these two readings cannot therefore be taken into account.

Date	Time	Time	Time	Time	Average Flow Rate	Average Meter Reading
89-05-20	09h07	09h38	10h08	10h35		
Meter Reading	114303	114334	114364	114396	63 l/h	114349

Note "B" The meter was not moving when the readings were commences but started to record after a hydrant upstream was opened for a few minutes.

89-05-27	09H08	10H00				
Meter reading	117351	117390			45 l/h	1173731
89-06-03	08h40	09h40	10h25			
Meter reading	120817	120598	120888		41 l/h	120853
89-06-10	09h07	09h50	10h00			
Meter reading	123624	123646	123651		42 l/h	123638
89-06-17	09h00	10h00				
Meter reading	127338	127377			39 l/h	127357
89-06-24	09h00	09h39	10h39			
Meter reading	131663	131681	131694	131708	30 l/h	131686

TABLE 13

Date	Meter Standard Flow kl	Leak kl	Adjusted Meter Standard kl
89-05-06	Begin		
89-05-20	3348	1058	2290
89-05-20	Begin		
89-05-27	3022	529	2493
89-06-03	3483	15	3468
89-06-10	2785	30	2755
89-06-17	3719	30	689
89-06-24	4329	1	4329

TABLE 14

Date	Meter Standard Flow kl (adjusted)	Total Outflow kl	Percentage under registration	Consumption kl/meter/day
89-05-06	Begin			
89-05-13	2290	1526	33	

See note "A" in Table 12

89-05-20

See note "B" in Table 12

TABLE 14 (continued)

Date	Meter Standard Flow kl (adjusted)	Total Outflow kl	Percentage under registration	Consumption kl/meter/day
89-05-27	2493	1907	24	1,8
89-06-03	3468	1751	49,5	1,7
89-06-10	2755	1281	53,5	1,2
89-06-17	3689	1517	58,9	1,5
89-06-24	4329	1735	60,0	1,7

Subsequent to the readings taken at Waterkloof Heights it was found that there was an additional draw-off from the area. This was recorded by the Meter Standard and also by a small bulk meter situated just outside the area considered. This bulk meter supplied the "Diplomatic Suburb" and records of previous consumptions is listed and recorded in Table 15.

TABLE 15

Date	kl per month
88-08-31	4339
88-09-23	3780
88-10-25	3156
88-11-26	3462
88-12-29	3620
89-01-25	3777
89-02-23	2889
89-03-28	3383
89-04-27	3868
89-05-27	3140
89-06-27	4362

For the period 89-05-27 to 89-06-24 the sum of the individual meter readings was 6284 kl and the total recorded by the Meter Standard was 14241 kl. Subtracting the flow for 89-05-27 to 89-06-27 of the Diplomatic Suburb meter of 4362 kl from the Meter Standard leaves a flow of 9879 kl. The difference between the sum of the individual meters and the Meter Standard is then 3595 kl, equal to an under-registration of 36%. However, if the Diplomatic Suburb meter is considered to be also a domestic meter then we get:

Sum of domestic meter 6284 + 4362 =	1064.6 kl
Meter Standard	14241 kl
Percentage under-registration	25%

5.7 Faerie Glen

This area was reinvestigated as the first set of results was considered to be unreliable because of the leaks and unrecorded draw-off from a fire hydrant (which was subsequently closed off).

TABLE 16

Date	Meter Standard in kl	Total of Individual Meters kl	Percentage under registration	Consumption kl/meter/day based on Meter Standard
89-07-01	Begin			
89-07-08	2322	1927	17	1,8
89-07-15	2499	2248	10	1,3
89-07-22	2242	1756	22	1,1
89-07-29	2422	2253	8	1,2
89-08-05	2516	2224	17	1,3

5.8 Waterkloof Heights

This area was again investigated and the following results obtained:

TABLE 17

(all flow rates in kl)

Date	Meter Standard	Total of individual meters	Percentage under registration
89-08-26	Begin		
89-09-02	4418	4053	8,3
89-09-09	4846	4517	6,8
89-09-16	5256	4730	10,0
89-09-23	5481	5011	8,6
89-09-30	5655	5205	8,0

Since the meter supplying the Diplomatic Suburb contributed considerably towards the total consumption, the results were analysed with this flow deducted, as shown in Table 18:

TABLE 18

(all flow rates in kl)

Dip. Sub.	Meter Standard	Total of Individual meters	Meter Std less Dip. Sub.	Total of Ind meters less Dip. Suburb	Percentage under registration
956	4418	4053	3462	3097	10,5
1142	4846	4517	3704	3375	8,9
1144	5256	4730	4112	3686	12,8
1249	5481	5011	4232	3762	11,1
1386	5655	5205	4269	3819	10,5

On 89-10-20 the Meter Standard (a combination Meineke meter), which was used at Waterkloof Ridge was tested by Messrs Liquid Meter, Isando in our presence and the following results recorded:

TABLE 19

Rate of Flow	Percentage Accuracy
240 kl/h	0,72 Fast
150 kl/h	0,52 Fast
85 kl/h	0,81 Fast

The By-pass meter was tested at a low flow rate, such that the main meter did not record, with the following results:

Rate of Flow	Percentage Accuracy
2,76 kl/h	0,4 Slow
1,28 kl/h	0,3 Slow

In view of these test results the accuracy of the Meter Standard was considered to be acceptable.

5.9 Koedoespoort

This area consisted of 60 meters all serving industries, and it was found during an initial site inspection on 89-11-02 that at least 25% of the meters were unreadable because of mud, dirt and beeswax covering them. A Council plumber was present and he undertook to have all the meters cleaned and covers loosened so that the student meter-readers could read them without difficulty. It was also found that a number of meters was recorded zero flow and this was reported to the Council, who replied that several of the large properties had their own boreholes, which would account for the very low consumption recorded by the meters. Also, two meters were jammed and had to be replaced. The Meter Standard which was used at Waterkloof Heights and subsequently checked by Messrs Liquid Meters and found to be accurate was used in this area.

The following results were recorded:

TABLE 20

Date	Meter Standard kl	Total Outflow kl	Percentage under registration	Notes
89-11-08	Begin			Meter Reading 170 000 kl
89-11-15	8759	7137	19,0	
89-11-23	10136	10092	0,4	
89-11-30	9429	8145	13,0	
89-12-07	25756	8556)		
			67,0	
89-12-21	12284	13153)		
90-01-04	12284			Factories closed
90-02-01	33905			Factories closed
90-02-16	16759	15246	9,0	
Average	117028	63212	46,0	Final Meter reading

These results are erratic and suggest that either the individual meters record sporadically (particularly during times of low flow when the factories were closed) or that the Meter Standard was faulty.

The Meter Standard was checked by Messers Liquid Meters on 89-03-12 and the following results were obtained:

TABLE 21

Rate of Flow	Main Meter flow, kl	By-Pass Meter flow, kl	Total Meter flow, kl	Percentage Error
250	9940	200	10140	1,4 Pos
225	9800	280	10080	0,8 Pos
150	9750	270	10020	0,2 Pos
50	4850	214	5064	1,3 Pos

This test shows that the Meter Standard is sufficiently accurate for this experimental purpose, and the results obtained from the readings at Koedoespoort cannot therefore be accepted as representative.

5.10 Capital Park

Because of the problems encountered at Capital Park, when it was subsequently found that there was an additional unmetered outflow from the area, the Council was requested to close off the discharge pipe, which was done, and a new set of readings was taken.

In this area, in order to isolate it hydraulically completely, arrangements were made to have Leak Detection Tests carried out on a regular basis. These tests showed up the following leaks:

TABLE 22

90-03-08	5,75 kl/hour = 966 kl/week
90-03-16	5,96 kl/hour = 1001 kl/week
90-03-23	1,72 kl/hour = (see below)

(A leak of 4,2 kl/h was measured and repaired at 10h30 on March 22, leaving a residual leak of 1,72 kl/hour)

The water loss for the week March 18 to 24 is therefore calculated as follows:

TABLE 23

5 days x 5,96 x 24	=	715 kl
2 days x 1,72 x 24	=	83 kl
		798 kl

TABLE 24

90-03-30	2,08 kl/hour	=	349 kl/week
90-04-06	2,30 kl/hour	=	386 kl/week
90-04-13	2,58 kl/hour	=	493 kl/week
90-04-20	2,08 kl/hour	=	349 kl/week
90-04-27	2,63 kl/hour	=	442 kl/week

The following readings were taken of the Meter Standard and the individual meters.

TABLE 25

Period	Meter Standard kl	Sum of individual meter kl	Leak kl	Meter Standard minus kl leaks
90-03-03 to 90-03-10	1715	1383	966	749
90-03-10 to 90-03-17	1755	1451	1001	751
90-03-17 to 90-04-07	3526	4210	1047	2479

There is apparantly an additional supply to the area and the Council was asked to investigate this on 90-03-22. Since a great deal of time had already been spent on this area a meeting was arranged with Prof Savage and Mr Fox and Mr M M du Toit, Dept City Engineer at the Council and Mr A Smook on 90-04-11 at 09h00.

The whole object of isolating areas was discussed and it was requested that the Council proceed with the Loggers so that that part of the research could be carried out simultaneously with the water-loss research. It was also pointed out that this research project was due to be finalised in a year's time and that the various actions to be undertaken by the Council be concluded timeously. Mr du Toit and Mr Smook agreed to do so.

On May 8, 1990 a team of Council employees and Prof Savage and Mr Fox carried out tests on this area and could find no additional supply apart from the one metered connection.

The only other possible source of error was therefore considered to be the Meter Standard, which was a combination meter reading bulk flow through the main meter and lesser flows through the by-pass meter.

At a meeting held at the Water Research Commission on 14 May 1990 this matter was discussed and the Council undertook to install a control meter in series with the Meter Standard in order to test its realiability at low flows. This was not done.

8. Because of the problems associated with the isolating of the

areas no further work in this connection was undertaken.

9. Loggers

The Council installed loggers in the following positions:

Valhalla - Hanlon Road, during the period 89-07-11 to 89-07-18:

Street No	Ref No	Record	Description of Property
21	1375	17	Well-watered lawn
22	1382	9	Better-type house
23	1373	13	Large lawn, well-watered
24	1384	16	Not well-kept
25	1371	14	Neat garden
26	1386	10	Small, neat garden
27	1369	12	Unkempt
29	1367	11	Small, good garden
30	1390	15	Small, neat garden

All the meters used were Castle Optima Inferential, No 3, with a rated capacity of 3000 l/hour (50 l/m). In all cases the rated flow rate of 50 l/m was not reached and a summary of the results obtained is shown in the following Table 27.

TABLE 27

Ref No	Total Flow l	Percentage of Total Flow at less than	
		Half of Rated Capacity - 25 l/m	Quarter of Rated Capacity-12,5 l/m
1367	1450	100	68
1369	7820	68	42
1371	9740	100	65
1373	3170	75	30
1375	3350	97	50
1382	7650	91	38
1384	7940	97	60
1386	5800	97	79
1390	6360	92	60
Average of 9 Loggers		91	55

Subsequent to the recording of Table 27 the nine meters were tested by the Council with the results below. Apparently the pulsing mechanism presents an additional load on the rotating inferential drum and at low flows the drum does not rotate at the designed speed.

TABLE 28

Street No	Percentage Accuracy at: 40 l/m	27 l/m	0,42 l/m	Meter No
23	- 2,6	- 2,8	- 90,0	305045
27	- 7,0	- 7,1	- 11,0	293324
25	+ 6,4	+ 6,2	- 3,0	22117
26	- 2,6	- 3,0	- 4,0	293293
24	- 2,2	- 2,3	- 10,0	293082
22	+ 1,7	+ 1,5	- 4,0	295916
30	- 0,6	- 1,7	- 9,0	293373
29	+ 0,6	+ 2,0	- 4,0	44212
21	- 1,6	- 2,1	- 6,0	289685

Because of the low accuracy of these meters, the Council considered replacing them with alternative ones but, because of the higher costs involved it advised this research team on 14 May 1990 that it was not proceeding with this and it would now commence the installation of the existing Loggers so that more comprehensive results could be obtained. Nothing further was done in this connection.

10. During these investigations the Council undertook the testing of a number of domestic water meters which had been removed from the various areas.

METER TESTS

A total of 72 meters were tested, with the results shown below.

In accordance with the Metrology Act, domestic meters are required to comply with the following:

	Meters in Use	New Meters
At 75% of the rated flow rate	- 3,5% accuracy	2,0% accuracy
At 50% of the rated flow rate	- 3,5% accuracy	2,0% accuracy
No 3 meter - at 25 l/hour	- 5,0% accuracy	3,5% accuracy
No 5 meter - at 30 l/hour	- 5,0% accuracy	3,5% accuracy
No 3 meter - 15 mm - Rated Maximum flow rate 3 kl/hour		
No 5 meter - 20 mm - Rated Maximum flow rate 5 kl/hour		

The testing rate is therefore:

No 3 meter at 75% of rated flow 37,5 l/m

No 3 meter at 50% of rated flow 25,0 l/m

low flow rate 0,417 l/m

No 5 meter at 75% of rated flow 62,5 l/m

No 5 meter at 50% of rated flow 41,7 l/m

low flow rate 0,5 l/m

Installation		Percentage Difference at rated flow				
		Type	Size mm	75%	50%	Low flow
Erf 1567	Waterkloof Ridge 11	Kent	20	-0,4	0,0	- 94,0
Erf 228	W/kloof Ridge 11	Kent	15	-1,2	-0,1	- 7,0
Erf 1593	" " "	Kent	15	-1,4	-1,4	- 1,0
Erf 1597	" " "	Kent	20	-0,1	-0,2	- 90,0
Erf 228	" " "	Kent	15	-1,2	-0,1	- 7,0
Erf 1593	" " "	Kent	15	-1,4	-1,4	- 1,0
Erf 1597	" " "	Kent	20	-0,1	-0,2	- 90,0
Erf 1535	" " "	Kent	20	-0,4	-0,0	- 92,0
Erf 1537	" " "	Kent	20	+0,3	+0,5	- 14,0
Erf 1722	" " "	Kent	20	-0,9	0,0	- 95,0
Erf 1752	" " "	Kent	15	-0,7	-0,7	- 1,0
Erf 1696	" " "	Castle	20	-0,6	-0,5	+ 4,0
Erf 1710	" " "	Kent	20	-0,1	-1,3	- 14,0
Erf 1748	" " "	Kent	15	-0,3	-0,3	- 0,0 (?)
Erf 1718	" " "	Kent	20	-2,9	-3,4	- 30,0
Erf 1715	" " "	Kent	3/4	-4,0	-4,4	-100,0
Erf 1563	" " "	Kent	15	-2,0	-2,1	- 3,0
Erf 1532	" " "	Kent	15	-1,5	-1,7	- 65,0
Erf 1603	" " "	Kent	15	-1,3	-1,8	- 90,0
Erf 1600	" " "	Kent	15	-0,2	-0,4	- 90,0
Erf 1575	" " "	Kent	15	+0,3	+0,1	- 4,0
Erf 1703	" " "	Kent	15	-0,6	-0,6	- 1,0
Erf 1560	" " "	Kent	15	-2,1	-2,4	- 14,0
Erf 510	" " "	Kent	15	-0,2	-0,6	- 5,0
Erf 181	Magalieskruin	Kent	15	+0,3	+0,1	- 2,0
Erf 127	"	Kent	20	-1,6	0,0	- 90,0
Erf 135	"	Kent	20	-0,8	-0,0	- 90,0
Erf 261	"	Kent	15	-0,5	-1,0	-100,0
Erf 186	"	Kent	15	-0,3	-0,3	- 4,0
Erf 213	"	Kent	15	+0,2	+0,2	- 54,0
Erf 197	"	Kent	15	-3,6	-4,0	- 92,0
Erf 205	"	Kent	15	-1,6	-1,6	- 90,0
Erf 245	"	Kent	15	-0,8	-0,5	0,0
Erf 572	"	Kent	15	-1,2	-1,1	0,0
Erf 218	"	Kent	15	-0,4	-0,4	- 3,0
Erf 289	"	Kent	15	+0,8	+0,6	1,0
Erf 476	"	Kent	15	-1,1	-1,0	0,0
Erf 173	"	Kent	15	-1,3	-1,4	- 90,0
Erf 248	"	Kent	15	-0,7	-0,6	- 3,0
Erf 251	"	Kent	15	+0,1	+0,1	- 4,0
Erf 192	"	Kent	15	+0,7	-0,5	- 3,0
Erf 501	"	Kent	15	-0,1	-0,1	- 7,0
Erf 209	"	Kent	15	+0,5	+0,5	- 85,0
Erf 505	"	Kent	15	-0,4	-0,4	- 7,0
Erf 462	"	Kent	15	+0,3	+0,2	- 6,0
Erf 200	"	Kent	15	-1,2	-1,1	- 1,0
Erf 542	"	Kent	15	-0,4	-0,7	- 93,0
Erf 151	"	Kent	15	-1,8	-14,0	- 33,0
Erf 293	"	Kent	15	+0,6	+0,4	- 3,0
Erf 507	"	Kent	15	-0,7	-0,6	- 3,0
Erf 514	"	Kent	15	-1,9	-1,7	- 1,0
Erf 157	"	Kent	15	-9,0	-8,2	-100,0

Installation		Percentage Difference at rated flow				
		Type	Size mm	75%	50%	Low flow
Erf 147	"	Kent	15	-1,1	-1,0	- 6,0
Erf 469	"	Kent	15	-1,3	-1,2	- 0,0
Erf 246	"	Kent	15	-1,4	-1,4	-100,0
Erf 496	"	Kent	15	-2,9	-2,7	- 2,0
Erf 254	"	Kent	15	-0,5	-1,4	- 22,0
Erf 452	"	Kent	15	+0,1	+0,1	- 4,0
Erf 536	"	Kent	15	-2,0	-9,8	- 91,0
Erf 551	"	Kent	15	-0,7	-0,8	- 2,0
Erf 440	"	Kent	15	-0,8	-1,2	- 4,0
Erf 555	"	Kent	15	-0,6	-0,8	- 17,0
Erf 285	"	Kent	15	-0,8	-0,6	- 7,0
Erf 518	"	Kent	15	-100,0	-100,0	-100,0
Erf 543	"	Kent	15	-0,3	-0,1	- 3,0
Erf 265	"	Kent	15	+1,5	+1,4	- 4,0
Erf 222	"	Kent	15	-0,1	-0,1	- 4,0
Erf 565	"	Kent	15	-1,1	-1,1	- 10,0
Erf 558	"	Kent	15	-0,7	-0,6	- 0,0
Erf 258	"	Kent	15	-3,0	-3,0	- 91,0
Erf 281	"	Kent	15	-6,6	-6,2	- 80,0
Erf 178	"	Kent	15	-1,0	-1,2	- 90,0

11. Conclusion

11.1 Insofar as the investigations of the various areas are concerned, only that of Valhalla, Table 6 shows any consistency, namely percentage under-registration for:

88-09-24 to 88-10-01 ———— 22,1%
88-10-01 to 88-10-08 ———— 18,8%
88-10-08 to 88-10-22 ———— 19,4%
88-10-22 to 88-10-29 ———— 22,8%

That is, there is an average of 20,8% under-registration by the domestic water meters as against the total inflow from the main supply. None of the other areas investigated, for the reasons stated under each heading, is in any way consistent and no reasonable conclusions can be drawn from them.

11.2 However, one conclusion that can, in fact, be drawn from them is that the control over possible leaks and other forms of unmetered outflow and inflow, warrants thorough and detailed investigations.

11.3 The results of the 72 meters removed from different areas and tested on the Council Test bed show that, at flows of 75% and 50% of the rated capacity of the meters the inaccuracy is, with few exceptions, within acceptable limits. However, at the Low Flow of

of 0,47 l/m for No 3 meters, and 0,5 l/m for No 5 meters the accuracy varies considerably and the results indicate extremely erratic meter function.

Unfortunately, only 9 Loggers were installed, each for one week, and consequently it would be unreasonable to attempt to draw any reliable conclusions from the results obtained. However, a certain pattern becomes apparent when considering these results, and this is shown in Table 27, namely that 91% of the total flow took place at not more than half the rated capacity of the meters, and that 55% took place at not more than 25%. The meters were tested and showed acceptable percentage accuracy at 40 l/m and 27 l/m but here again the results obtained at 0,43 l/m are quite inconsistent.

From an analysis of the data submitted on the Loggers it can be said that there appears to be little justification for testing the domestic water meters at the low flow rates as laid down in the Metrology Act, and here again considerably more investigations are warranted and necessary before any firm recommendation can be made.

11.4 Finally, it is with regret that the research team has to report that, because of inadequate preparations of the various areas investigated, and the fact that only 9 Loggers were made available, no conclusive results emanated notwithstanding the considerable efforts made by this team during the course of the entire research project.

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