Overall effect on annual costs of a reduction in water use with separate metering of flats in Pretoria

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Abstract

An investigation by the Building Services Division of the Division of Building Technology of the CSIR for the Water Research Commission indicated that individual metering of flats in Pretoria results in a saving of 25% in water use compared to that for a block of flats with a single bulk meter. Based on the unit costs for 1986 it was concluded, however, that the cost of water supply would be increased by about 8% for consumers in a block of 60 flats. This estimate did not, however, take into account the effect of a reduction in demand on capital expenditure and on the associated annual capital charges.

A study of the water supply and the expenditure thereon for the Rand Water Board and for Pretoria showed that in the long run, in spite of substantial annual deviations, there is a relatively firm relationship between the cumulative capital expenditure and the annual volume of the water supply. This confirms the logical conclusion that a reduction in water demand or in the growth rate thereof will in the long run lead to a relative reduction in capital expenditure and ultimately to a relative reduction in the annual capital charges for water supply. Although the reduced demand will initially lead to increased unit costs for water, this effect will be eliminated with a resumption or continuation in the growth of the supply, probably within two years. A comparison of costs is complicated by the effects of inflation, increased costs for developing new water supplies and annual variations in the rate of growth in water demand, but the study shows that there will be an economic advantage in reducing the consumption of water.

It is concluded that if the effect on capital expenditure of the reduction in water use by individually metering the hypothetical block of sixty flats in Pretoria is taken into account it will, instead of increasing the costs of water supply by 8%, after a few years result in a cost reduction of about 20%. These percentages are valid only for the case considered, but it is believed they indicate a trend which will be of wide application.

1. Introduction

During the years 1985 to 1987 the Building Services Division of the Division of Building Technology of the CSIR carried out research for the Water Research Commission on the effect of separate metering of flats on water use and on the cost of supplying the water to a block of flats (Malan, 1988). By actual measurement on two identical blocks of flats in Pretoria it was found that there was a reduction of 25% in the water consumption of the block with individual metering of flats compared to that of the block with a single bulk meter. A similar result was indicated in a comparison of the water use in separately metered and bulk-metered flats in East London.

A cost analysis was made of the annual costs for a hypothetical block of 60 flats with and without individual metering based on representative water use figures and prices in 1986. These were as follows:

- Average water consumption per flat with a single water meter for the block of 60 flats — 400 ℓ/d
- Average water consumption per flat with separate metering of flats — 300 ℓ/d
- Unit costs of water delivered to consumers:
  - (a) In respect of water purchases (mainly from Rand Water Board) — 28c/m³
  - (b) In respect of distribution of water to sites — 17c/m³
  - (c) Total cost of water delivered to site — 45c/m³
- Cost of water reading @ R1,67 per month per meter — R20/a per meter
- Cost of water meter maintenance:
  - (a) For single bulk meter = R23 per month — R276/a
  - (b) For individual metering of flats = R35 per month — R420/a

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On this basis it was found that the annual cost of water supply to the flats would be R4 238/a for the bulk metered block of flats and R4 577/a for the 60 separately metered flats, equivalent to R5,89 and R6,36 per flat per month respectively. The additional cost of supply to the separately metered flats is, therefore,

TABLE 1
AVERAGE INFLATION RATES AND VALUE OF MONEY BASED ON YEAR TO JUNE 1984

Year ending	Average inflation based on consumer price index	Average value of money for year in terms of that for year ending June 1974
	%/a	%
June 1970	–	133,24
June 1971	5,6	126,17
June 1972	6,3	118,70
June 1973	8,2	109,70
June 1974	9,7	100,00
June 1975	14,0	87,72
June 1976	11,9	78,391
June 1977	11,1	70,559
June 1978	10,7	63,739
June 1979	12,1	56,859
June 1980	13,9	49,920
June 1981	14,6	43,560
June 1982	15,2	37,813
June 1983	13,8	33,227
June 1984	11,0	29,934
June 1985	14,1	26,235
June 1986	17,6	22,309
June 1987	17,8	18,938

Note: Calculated from tabulation of monthly figures obtained from Central Statistical Services (1970-1987).

Average inflation rate: June 1970 to June 1974 : 7,44%/a
June 1974 to June 1984 : 12,82%/a
June 1984 to June 1985 : 16,49%/a
June 1985 to June 1987 : 17,70%/a

R399/a, i.e. about 8% more than to flats metered in bulk.

The above estimate, however, did not take into account the possible effect of a reduction in demand on future capital expenditure and the decrease in subsequent annual capital charges resulting therefrom. This aspect is addressed in this study.

2. Capital expenditure in relation to water supply requirements

2.1 It is obvious that with an increased demand for water, the capital expenditure on the water supply system to supply the needed water will be increased. Because of the need to plan ahead there will not be a direct relationship between water consumption and capital expenditure in the early stages of a water supply system or when a major augmentation scheme has to be implemented. In the long run, however, and particularly with a mature well-developed water supply system with a continued growth in demand, the cumulative capital expenditure will tend to be directly related to the demand for water. This means that over a period of normal demand growth the average annual growth rate in capital expenditure will be related to the average annual growth rate in water consumption. Due to climatic conditions which vary from year to year, and other factors, the growth rate in water demand is never quite uniform from year to year and the yearly capital expenditure also varies depending on the nature of the works to be constructed and the rate of inflation. The result is that the relationship between cumulative capital expenditure and water consumption is subject to deviations from the average from year to year, but this does not detract from the fact that over the longer term such a relationship does exist.

2.2 The rate of growth in capital expenditure will generally be greater than the rate of growth in water demand because:

- inflation results in a greater expenditure in money terms per unit of water supplied; and

TABLE 2
RAND WATER BOARD
WATER SUPPLIED TO CONSUMERS AND CAPITAL EXPENDITURE

Year ending	Water supplied to consumers		Capital expenditure					
			Actual			Adjusted for inflation to 1973/74 money value		
		Average annual growth rate	For year	Cumulative total	Average annual growth rate	For year	Cumulative total	Average annual growth rate
	10^6 m^3		R10^6	R10^6		R10^6	R10^6	
RAND WATER BOARD (1970-1987)								
March 1970	368,9			108,48				
March 1971	403,2		8,54	117,02		–	112,56	
March 1972	414,0		12,38	129,40		14,69	127,25	
March 1973	486,7		16,88	145,96		18,51	145,76	
March 1974	599,8		16,96	162,72		16,96	162,72	
March 1975	538,7	March 1973	9,60	172,37	March 1974	8,42	171,41	March 1974
March 1976	585,5	to	15,18	187,50	to	11,90	183,04	to
March 1977	617,4		31,19	218,96		22,01	205,05	
March 1978	639,7	March	40,72	259,41	March	25,95	231,00	March
March 1979	692,8	1983	30,91	290,33	1984	17,58	248,58	1984
March 1980	676,1	10 years	22,11	312,44	10 years	11,04	259,61	10 years
		5,78%			12,96%			7,67%
March 1981	735,1		29,95	342,49		13,05	272,66	
March 1982	788,2		42,28	384,87		16,06	288,72	
March 1983	853,6		71,49	456,35		23,75	312,47	
March 1984	662,7		94,23	550,58		28,21	340,68	
March 1985	629,6		59,27	609,85	March 1984	15,55	356,23	March 1984
					to			to
March 1986	653,7		43,53	653,38	March 1987	9,71	365,94	March 1987
March 1987	664,4		71,15	724,53	3 years	13,48	379,42	3 years
					9,58%			3,66%

Note: 1. Restrictions in water supplies from the Vaal River were imposed as follows:

January	1969	– November	1969	– Restrictions less than 10%
October	1970	– November	1971	– Restrictions less than 10%
October	1973	– February	1974	– Restrictions less than 10%
June	1979	– February	1980	– Restrictions less than 10%
March	1983	– 3 October	1987	– Severe restrictions of 30%

TABLE 3
PRETORIA MUNICIPALITY
WATER SUPPLIED TO CONSUMERS AND CAPITAL EXPENDITURE

Year ending	Water supplied to consumers		Capital expenditure					
			Actual			Adjusted for inflation to 1973/74 money value		
		Average annual growth rate	For year	Cumulative total	Average annual growth rate	For year	Cumulative total	Average annual growth rate
	10^6 m^3		R10^6	R10^6		R10^6	R10^6	
PRETORIA MUNICIPALITY (Data obtained from City Engineer's Department 1985 to 1987 and Pretoria City Treasurer's Department May 1987)								
Dec 1970	59,06		–					
Dec 1971	58,39		–					
Dec 1972	70,93		–					
Dec 1973	72,18		–			–		
June 1974	–		–	22,0		–	22,00	
Dec 1974	71,88		–	–		–	–	
June 1975	73,9	December	1,76	23,76	June	1,54	23,54	
Dec 1975	77,66		–			–	–	
June 1976	77,8	1970	2,19	25,95	1974	1,72	25,26	June
Dec 1976	81,15		–	–		–	–	
		to			to			1975
June 1977	82,5		3,75	29,70		2,65	27,91	
Dec 1977	84,30	December	–	–	June	–	–	to
June 1978	85,9		4,97	34,66		3,17	31,07	
Dec 1978	89,26	1982	–	–	1984	–	–	June
June 1979	93,7		3,00	37,67		1,71	32,78	
Dec 1979	89,59	12 years	–	–	10 years	–	–	1984
June 1980	87,1	4,94%	3,06	40,72	11,22%	1,52	34,30	9 years
Dec 1980	95,64		–	–		–	–	
June 1981	97,4		3,51	44,23		1,53	35,83	
Dec 1981	100,72		–	–		–	–	
June 1982	96,8		4,66	48,89		1,76	37,59	
Dec 1982	198,79		–	–		–	–	
June 1983	100,8		3,98	52,87		1,32	38,91	
Dec 1983	80,94		–	–		–	–	
June 1984	77,3		10,84	63,71		3,24	42,16	
Dec 1984	69,31		–	–		–	–	
June 1985	76,0		9,58	73,29	June	2,51	44,67	June
Dec 1985			–	–	1984	–	–	1984
					to			to
June 1986	77,55		9,30	82,59	June	2,07	46,75	June
Dec 1986	77,93		–	–	1987	–	–	1987
March 1987	78,0		–	–	3 years	–	–	3 years
June 1987			10,15	92,84	13,37%	1,90	48,65	4,89%

Note: 1. Water supplied to consumers in Pretoria based on actual records are given to two decimal figures. Figures given to one decimal are estimated on the basis that of the total water supply 12% is not accounted for.

2. The cumulative total for Pretoria up to June 1974 was not available and was estimated on the basis that it was in approximately the same proportion to the total up to 1987 as in the case of the Rand Water Board which started supplying water in 1905.

3. Capital expenditure for Pretoria in respect of the years ending June 1986 and 1987 included R200 000 and R4 000 000 respectively spent on emergency water schemes and expansion of Pretoria's own water supplies. These are not directly related to the cost of water distribution to consumers and are excluded here.

4. Restrictions in water supplies from the Vaal River were imposed as follows:

January	1969	–	November	1969	– Restrictions less than 10%
October	1970	–	November	1971	– Restrictions less than 10%
October	1973	–	February	1974	– Restrictions less than 10%
June	1979	–	February	1980	– Restrictions less than 10%
March	1983	–	3 October	1987	– Severe restrictions of 30%

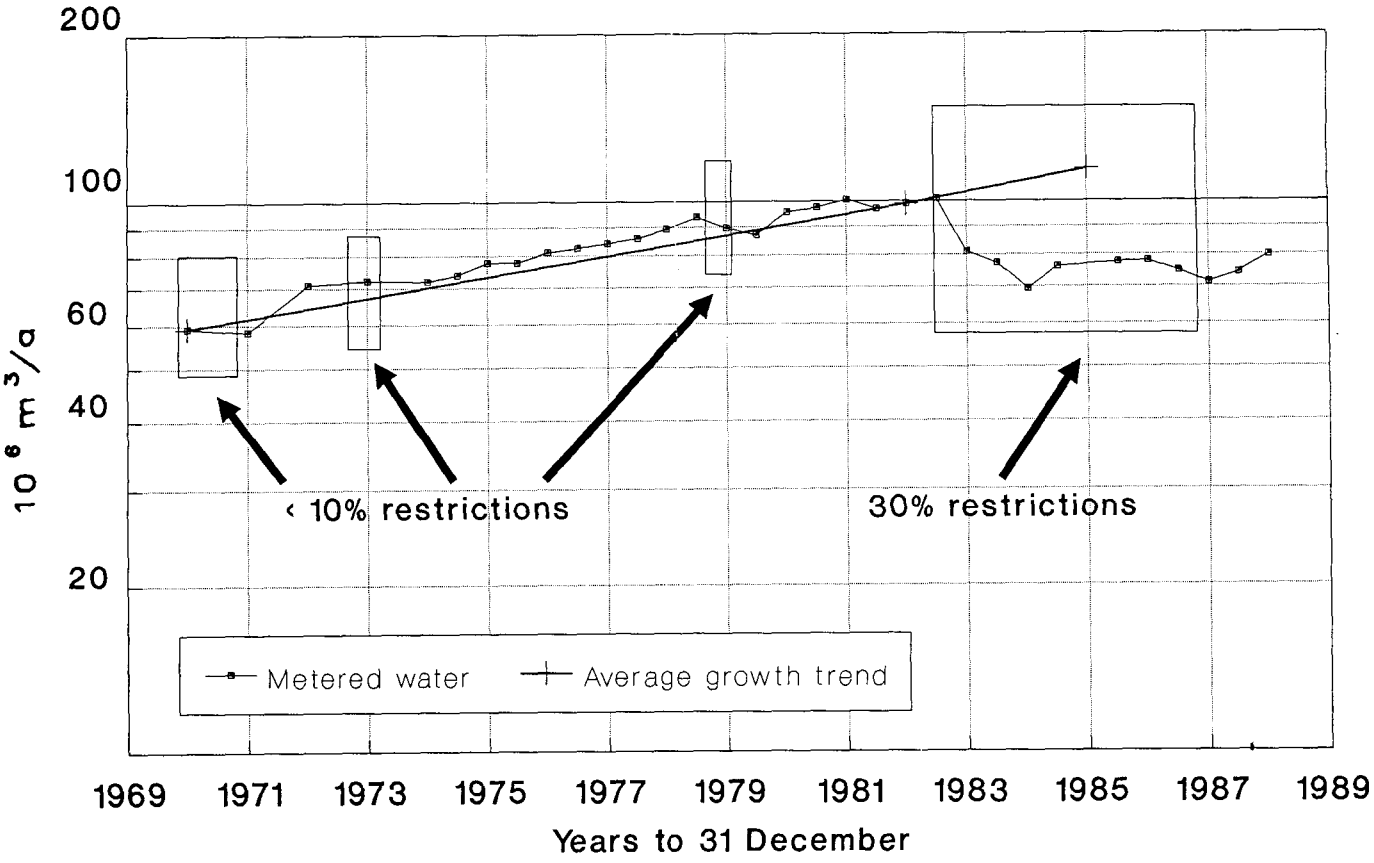

Figure 1a
Water supply to Pretoria.

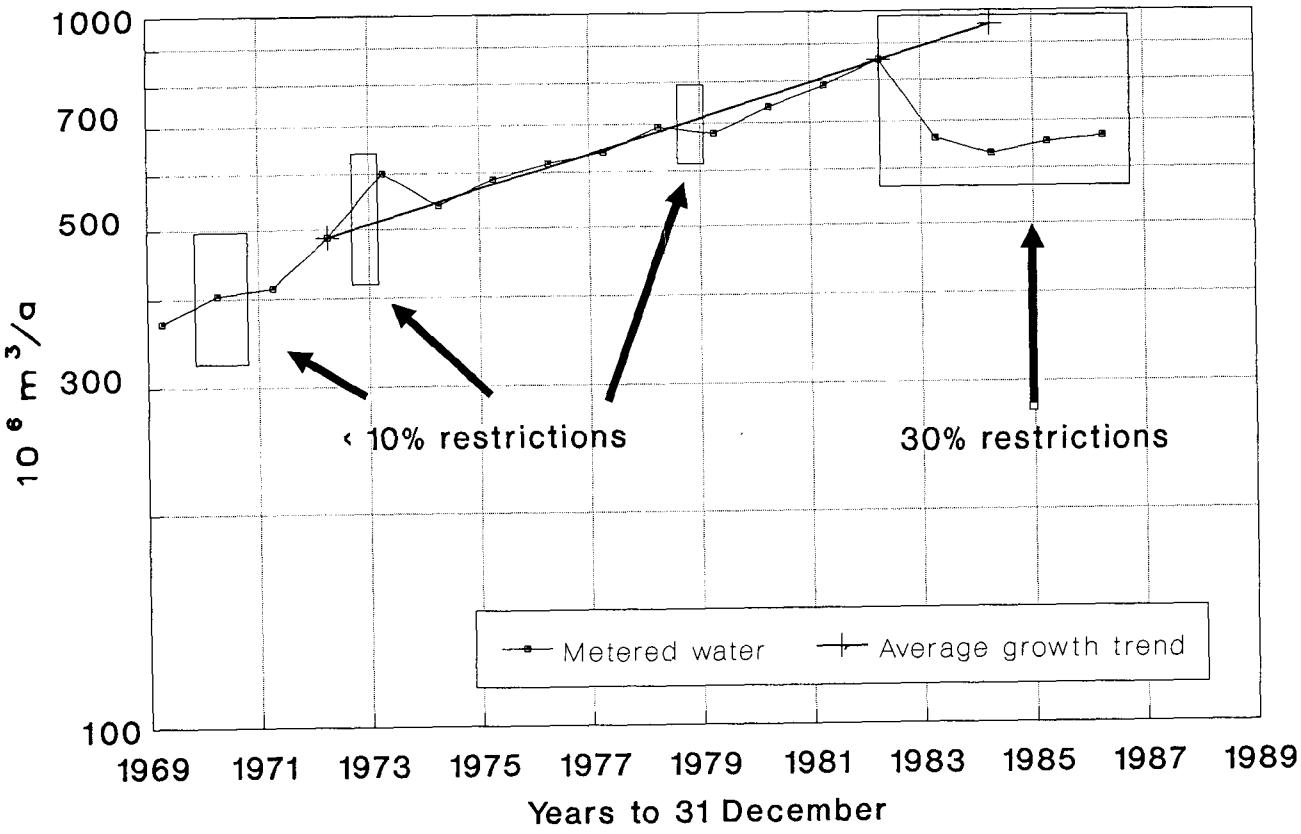

Figure 1b
Water supply by Rand Water Board.

- with an increasing supply local water sources become inadequate so that increased supplies have to be transported over longer distances and new augmentation schemes are generally more expensive to develop.

2.3 The increasing rate of inflation from 1970 to 1987 is illustrated by the data for the average yearly inflation for years ending in June as given in Table 1, calculated from monthly values of the consumer price index (CPI) supplied by the Central Statistical Services (1970-1987). The table also shows the decreasing value of money due to inflation, which means that expenditure in money terms for the same real value of work done has increased dramatically over the period of 17 years.

2.4 In fact the actual inflation in costs for the civil engineering industry has increased at a higher rate than the CPI, being of the order of 19% for the year ending June 1987 when the CPI was 17,8%, but as the overall index for any particular type of work depends on a number of factors not readily definable, the approximation of using the CPI for estimating purposes is used, as this will be conservative.

2.5 For the Rand Water Board and for Pretoria the annual quantity of water supplied to consumers, the actual annual capital expenditure, the cumulative capital expenditure to the end of every year and the capital expenditure figures adjusted for inflation to prices ruling in 1973/74 are given in Tables 2 and 3 for those years after 1970 for which data could be obtained. The water supply and capital expenditure data have been plotted in Figs. 1 and 2 to semi-logarithmic scales so that average annual exponential growth rates can be readily derived.

During the period considered there were minor restrictions of 10% or less on water use from the Vaal River for short periods in 1970/71, 1973/74 and 1979/80 as listed in the table and shown in Figs. 1 and 2. These did not affect the normal growth patterns materially, but severe restrictions of 30% imposed in March 1983 up to November 1987 completely disrupted the growth trend in the water supply to consumers.

2.6 From the data in Tables 2 and 3 the actual and real cumulative capital expenditures up to the end of the previous year per unit of water supplied to consumers during the year concerned have been calculated and are shown in Table 4. The real cumulative capital expenditure (adjusted for inflation) per unit of water supplied during the next year has also been plotted in Fig. 3.

2.7 The average exponential growth rates determined from the growth trend lines on the graphs in Figs. 1 to 3 and as noted in Tables 2, 3 and 4 have been summarised in Table 5, in which the ratios of the growth rates for cumulative capital expenditure to the corresponding ones for water supply are also given.

2.8 The similarities between the growth rates as shown in Figs. 1 to 3 and summarised in Table 5 for the two water supply systems as well as in the ratios of growth rates are striking. It will also be noticed from the graphs that the reductions in water supply growth rates due to restrictions were generally associated with or followed within a year by temporarily reduced rates of growth in capital expenditure. In the case of

TABLE 4
CUMULATIVE CAPITAL EXPENDITURE PER UNIT OF ANNUAL WATER SUPPLY

Year ending	Actual cumulative capital expenditure to end of previous year per unit of water supplied to consumers during the year.	Real cumulative capital expenditure (Adjusted for inflation to 1973/74 prices) to end of previous year per unit of water supplied to consumers during the year.
	RAND WATER BOARD	
March 1971	R0,269	R0,252
March 1972	0,283	0,272
March 1973	0,266	0,281
March 1974	0,292	0,291
March 1975	0,302	0,302
March 1976	0,294	0,293
March 1977	0,204	0,296
March 1978	0,324	0,316
March 1979	0,374	0,333
March 1980	0,429	0,367
March 1981	0,425	0,353
March 1982	0,434	0,346
March 1983	0,451	0,338
March 1984	0,689	0,472
March 1985	0,874	0,521
March 1986	0,933	0,515
March 1987	0,983	0,551
	PRETORIA	
June 1975	R0,298	R0,298
June 1976	0,305	0,303
June 1977	0,315	0,306
June 1978	0,346	0,325
June 1979	0,370	0,332
June 1980	0,432	0,376
June 1981	0,418	0,352
June 1982	0,457	0,370
June 1983	0,485	0,373
June 1984	0,684	0,500
June 1985	0,838	0,555
June 1986	0,949	0,576
June 1987	1,058	0,599

The average annual growth rates for the real capital expenditure per unit of water supplied during the more or less normal supply period up to 1983 are as follows:

	For actual capital expenditure	For real capital expenditure
Pretoria, period 1975 to 1983	6,28%/a	2,43%/a
Rand Water Board, period 1972 to 1982	4,37%/a	2,44%/a

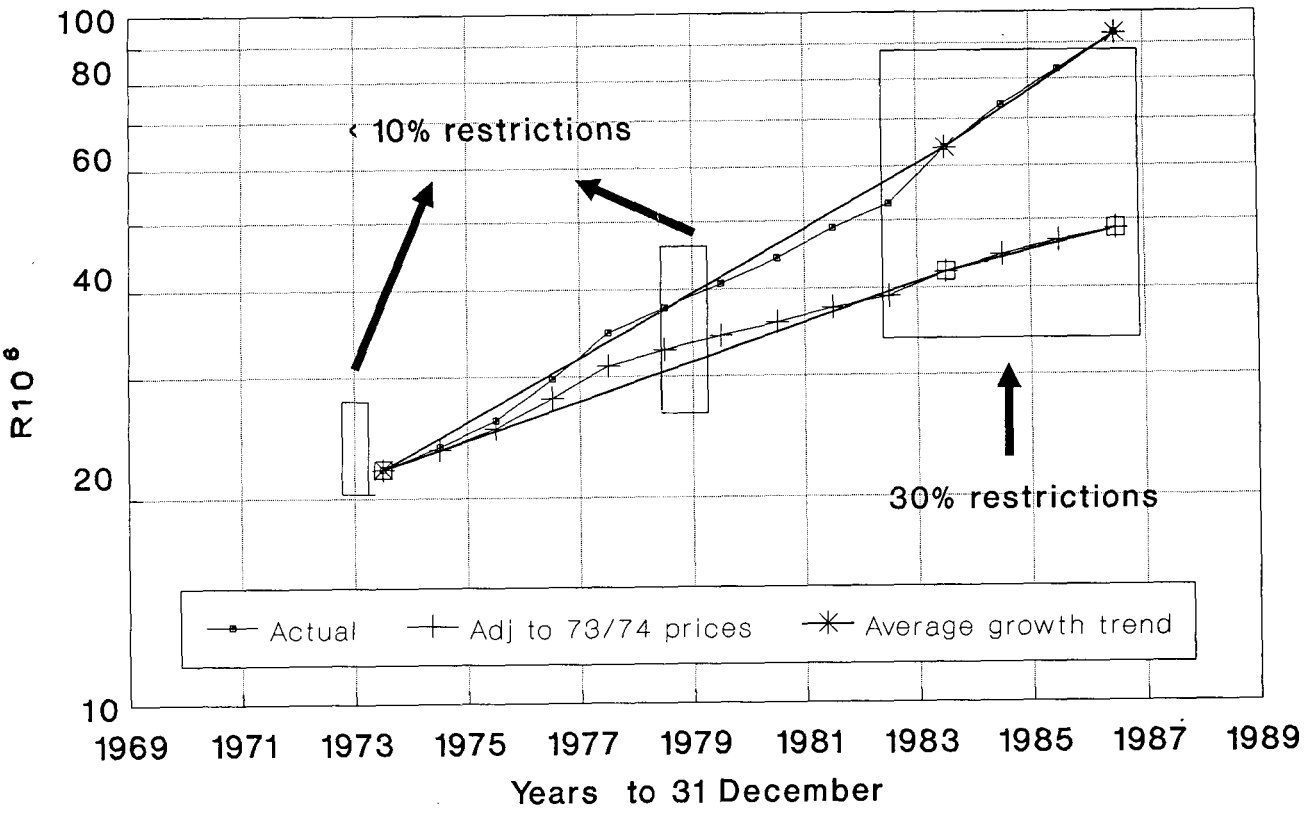

Figure 2a
Pretoria: Cumulative capital expenditure on water supply.

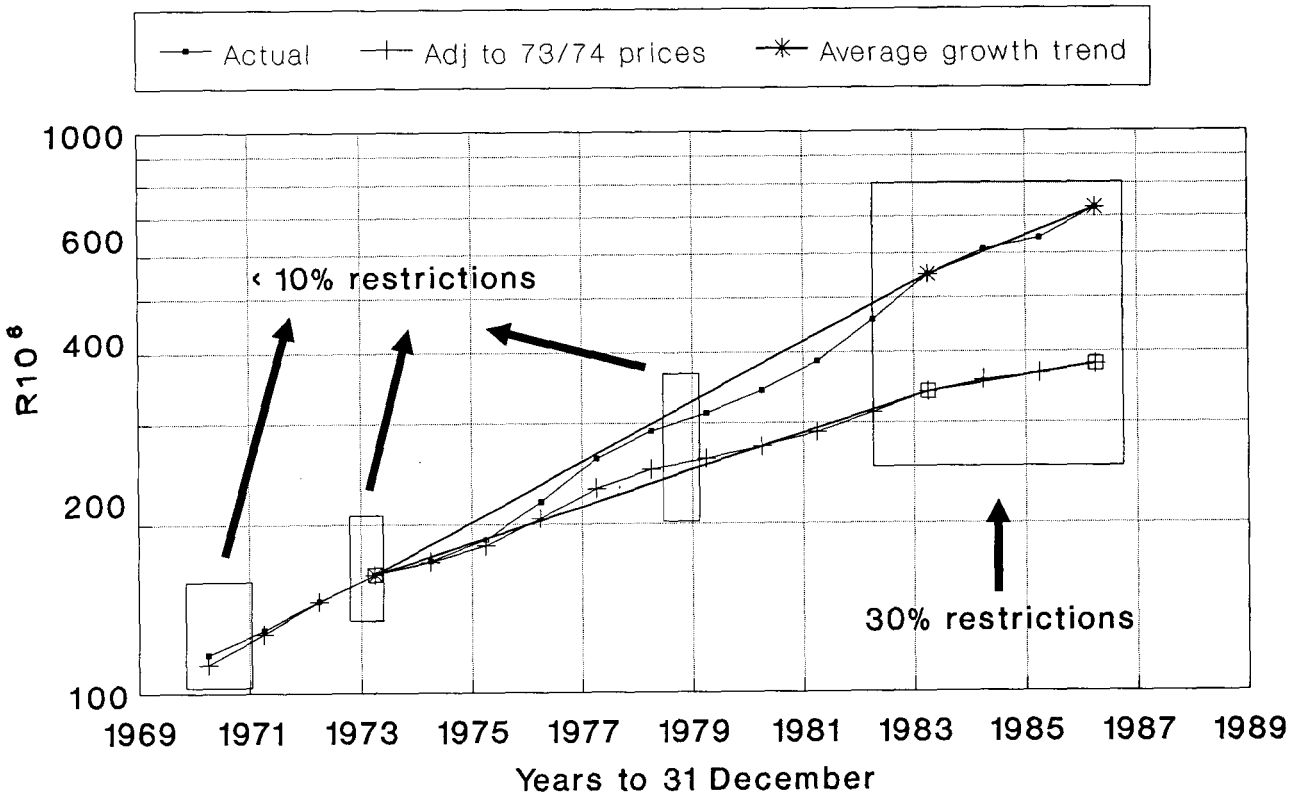

Figure 2b
Rand Water Board: Cumulative capital expenditure on water supply.

TABLE 5
EXPONENTIAL GROWTH RATES FOR WATER SUPPLIED TO CONSUMERS AND FOR CUMULATIVE CAPITAL EXPENDITURE

		RAND WATER BOARD			PRETORIA		
		Years ending	Period	Average annual growth rate	Years ending	Period	Average annual growth rate
		(a) Normal growth period up to 1983/84					
1.	Water supplied to consumers	March	1973/83	5,78%/a	December	1970/82	4,94%/a
2.	Actual cumulative capital expenditure	March	1974/84	12,96%/a	June	1974/84	11,22%/a
3.	Cumulative capital expenditure adjusted for inflation	March	1974/84	7,67%/a	June	1975/84	6,69%/a
		(b) Growth rates during severe restrictions after March 1983					
4.	Actual cumulative capital expenditure	March	1984/87	9,58%/a	June	1984/87	13,37%/a
5.	Cumulative capital expenditure adjusted for inflation	March	1984/87	3,66%/a	June	1984/87	4,89%/a
		(c) Ratios of rates of growth for capital expenditure and water supplied for normal growth period					
			Ratio of growth rates			*Ratio of growth rates*	
6.	Actual capital expenditure to water supplied to consumers: (2) – (1)		1974/84	2,24		1974/84	2,27
				Average ratio 2,255 say 2,26			
7.	Capital expenditure adjusted for inflation to water supplied to consumers: (3) – (1)		1973/84	1,33		1974/84	1,35
				Average ratio 1,34			
		(d) Normal growth rate for cumulative capital expenditure per unit of water supplied during next year					
8.	Based on actual cumulative capital expenditure	March	1972/82	4,37%/a	June	1975/83	6,28%/a
9.	Based on inflation adjusted (real) capital expenditure	March	1972/82	2,44%/a	June	1975/83	2,43%/a

Pretoria this effect after 1983 does not show for the actual expenditure, which was affected by the high inflation rate of 16,5% from 1984 to 1987, compared to the average of 12,8% from 1974 to 1984, but on the inflation-adjusted graph the effect is confirmed. For both water supply systems it will be noticed from item (5) of Table 5 that the inflation-adjusted rate of growth in capital expenditure for 1984/87 after the major restrictions in March 1983, was substantially less than that during the normal growth period preceding 1983.

2.9 From the preceding remarks and on the basis of the graphs in Figs. 1 to 3 and the data summarised in Table 5 the following conclusions are reached:

(i) In spite of short-term deviations from the growth trends which, as explained in para. 2.1, can be expected, expenditure over the longer term is directly related to the annual quantity of water supplied to consumers as suggested in para. 2.1.

(ii) On the average a reduction in demand for water can be expected to lead to a proportionate reduction in capital expenditure during the next year resulting in a reduction in annual capital charges during the second year compared to what it would have been if the reduction in demand had not taken place. The decrease in capital charges is not likely to be self-evident because the effect will be masked by inflation, increasing interest rates and annual variations in water demand or capital expenditure, but it will be real in the long term nonetheless.

(iii) For both Pretoria and the Rand Water Board the ratio of the rate of growth in capital expenditure to the rate of growth in the water supply can, for estimating purposes, be taken as equal to 2,26, as given in item (6) of Table 5, over a period of a few years if a normal growth period similar to that before 1983 is re-established. It should be noted that this ratio incorporates the effect of inflation over the period as well as the effect of increasing costs for developing new water sources and transporting the water over longer distances. The latter effect is reflected in the lower value of 1,34 for the ratio given in item (7) of the table. The difference in the two effects is also shown by the growth rates in capital expenditure per unit of annual water supply given in

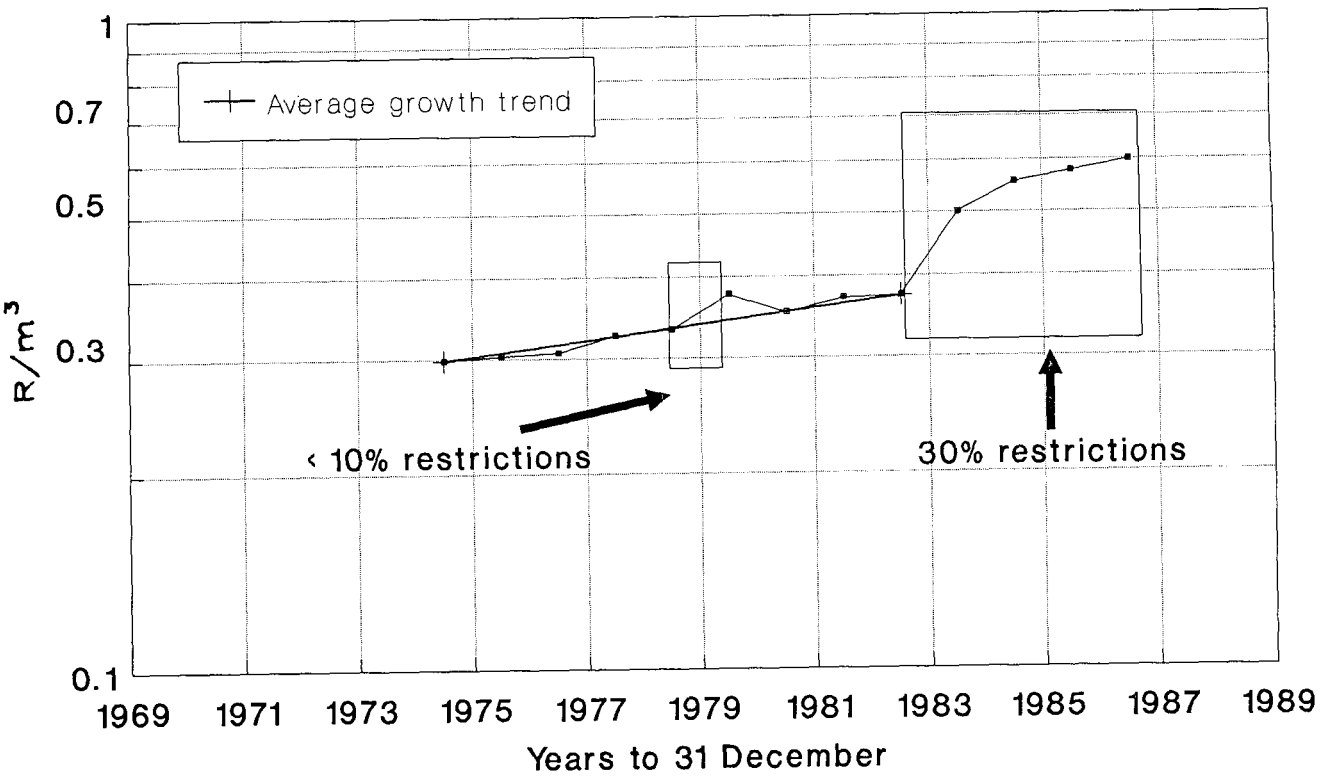

Figure 3a
Pretoria: Real cumulative capital expenditure/unit water supplied during following year. Reduced to 1973/1974 prices.

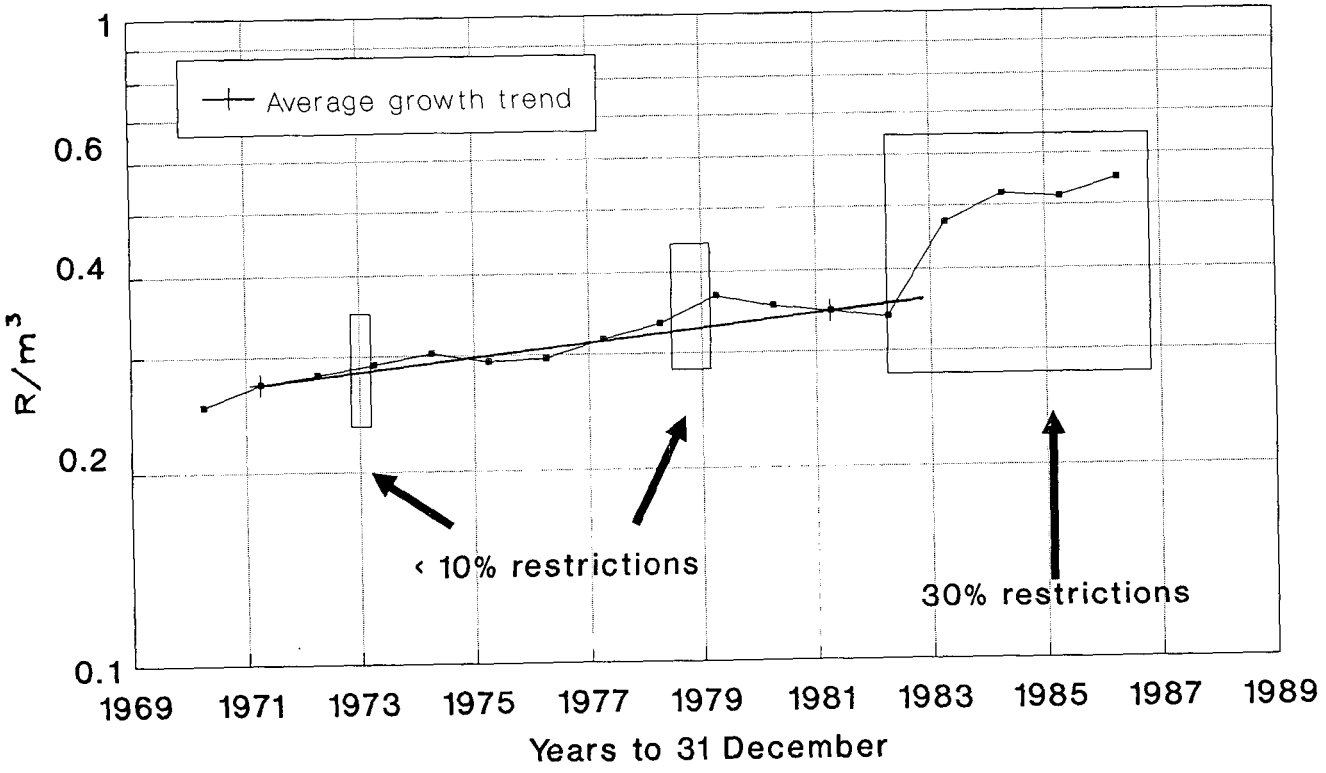

Figure 3b
Rand Water Board: Real cumulative capital expenditure/unit water supplied during following year. Reduced to 1973/1974 prices.

items (8) and (9), for the more or less normal growth period up to 1983.

(iv) Items (6), (7), (8) and (9) in Table 5 confirm the statement in para. 2.2. that the capital expenditure on water supply grows at a higher rate than the water supply itself even without inflation and that the ratio is further increased by inflation. A very large water augmentation scheme like the Lesotho Highlands Project may well further increase the ratios, but for the next few years until the project is implemented, the given ratios are a good approximation for estimating purposes.

3. Rate of growth in water demand by consumers

In a separate study for the Department of Water Affairs it was found that the average growth in the water demand for the two water supply systems closely followed the following exponential growth trends.

Pretoria	: Overall demand 49 years from 1925 to 1983	: Average growth rate 4,93%/a.
Rand Water Board	: Water supplied to consumers 41 years from 1942 to 1983	: Average growth rate 5,37%/a.

These long-term growth rates are in close agreement with the growth rates of 4,94% and 5,78%/a respectively shown in Table 5 for the decade before the restrictions of March 1983. There are strong indications that after the lifting of restrictions, a growth rate of the order of 5%/a will be resumed for the near future, and this figure is accepted for estimating purposes. There are strong arguments in favour of adopting a normal growth period for estimating the effect of a saving in water on capital expenditure, as such an estimate should not be influenced unduly by exceptional circumstances such as were experienced during the severe water restrictions after 1983.

4. Annual costs of water supplied to consumers

4.1 The annual costs of supplying water to consumers can be subdivided into categories as follows:

(i) Annual capital charges consisting mainly of interest on and redemption of loans. The magnitude of the annual capital charges in general depends on the cumulative capital expenditure up to the end of the previous year less the loans redeemed to the end of that year and on the ruling interest rates, which have tended to increase over the past 20 years. As a general rule the annual capital charges amount to between 50% and 60% of the total annual cost, excluding water purchases, of distributing water to consumers.

(ii) Annual working costs, consisting mainly of the costs of maintenance, pumping, materials and administration, the cost of meter reading being included.

(iii) The cost of water purchased from bulk suppliers. The total annual costs for supplying water to consumers for Pretoria from 1974 and for the Rand Water Board from 1970 are given in Table 6.

4.2 It will be noted from column 6 of Table 6 that the annual capital charges varied between 46,3% and 60% of the annual working costs excluding water purchases, with weighted averages of 51,1% for Pretoria and 53,4% for the Rand Water Board over the periods of record shown. It would be reasonable to adopt an average value of 52% for estimating purposes.

As the annual capital charges form a substantial proportion of the total annual costs it is evident that in assessing the effect of a reduction in demand on the cost of water, the impact that such a reduction may have on the annual capital charges should also be considered.

4.3 Column 3 of Table 6 shows that the annual capital charges expressed as a percentage of the capital expenditure to the end of the previous year had a slowly rising tendency, possibly as a result of rising interest rates. In actual fact the annual capital charges are related to the cumulative capital expenditure less loans redeemed previously. The total values of outstanding loans were not readily available, however, and in view of the consistent trends of the percentages shown in column 3 it appears to be a reasonable approximation to base an estimate of the annual capital charges on these percentages. The fact that the percentages would be higher if allowance were made for loans which had been redeemed, will to some extent counteract the error in estimating the annual capital charges on the larger amount of cumulative capital expenditure. The fact that a small proportion of the capital expenditure (on the average less than 10% of the total in the case of Pretoria) has been financed from revenue will not affect a comparison of costs materially because revenue used for this purpose is derived from a direct charge to consumers. On the basis of the percentages for the last four years (1984 to 1987) the annual capital charges amounted to 11,8% of the cumulative expenditure to the end of the previous year in the case of Pretoria and to 13,9% in the case of the Rand Water Board and these percentages are accepted for estimating purposes.

4.4 It has been calculated for columns 7 and 8 of Table 6 that the cost of water purchased remained nearly constant at 59,0% of the total cost of water supplied in Pretoria and 10,9% of the water supplied by the Rand Water Board from 1975 to 1987. The large difference is due to the fact that Pretoria buys purified water delivered to its distribution system while the Rand Water Board buys raw water in the Vaal River. It is evident that a reduction in demand in Pretoria would have a secondary effect on the quantity of water supplied by the Rand Water Board. Conversely the cost of distributing the water to consumers amounts to 41,0% and 89,1% of the total cost of water for Pretoria and the Rand Water Board respectively.

In actual fact Pretoria obtained part of its water supply from its own sources, i.e. the Fountains springs, a number of boreholes and Rietvlei Dam. The water supplied by its own sources remained fairly constant from 1980 to 1987 and amounted to 23,4 per cent of the city's total consumption. It is evident that changes in demand would primarily affect the quantity of water purchased from the Rand Water Board.

5. Unit cost of supplying water to consumers

The unit cost of supplying water to consumers for every year is

derived by dividing the total annual costs for the year by the quantity of water supplied during that year. The unit costs for the Rand Water Board and Pretoria since 1970 and 1975 respectively are given in Table 7.

The rapid increase in unit costs over the years due to inflation, to the extra costs of conveying water over longer distances and to increasing rates of interest is self-evident.

6. Effect of a reduction in water demand on unit costs

6.1 With a reduction in demand over a short period the initial effect will be to increase the unit cost as the annual costs will not be reduced immediately. In the case of the large reductions of over 25% in water demand after the severe restrictions imposed in March 1983 on the use of water from the

TABLE 6
RAND WATER BOARD AND PRETORIA MUNICIPALITY
TOTAL ANNUAL COSTS OF WATER SUPPLY

Year ending	Annual capital charges (Interest redemption, loan flotation, allocation to funds and for capital expenditure from revenue)		Annual working costs	Subtotal Total annual running costs (2) + (4)	Capital charges as a percentage of subtotal (2) ÷ (4) x 100	Water purchased	Total annual costs (5) + (7)
	$R10^6$	Per cent of cumulative capital expenditure to end previous year (Tables 2 and 3)	$R10^6$	$R10^6$	%	$R10^6$	$R10^6$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RAND WATER BOARD							
March 1970	7,699		5,728	13,427	57,3	0,354	13,781
March 1971	7,444	6,9	6,579	14,023	53,0	0,494	14,517
March 1972	8,022	6,9	7,233	15,257	52,6	0,584	15,839
March 1973	12,275	9,5	9,018	21,293	57,6	0,858	22,151
March 1974	12,381	8,5	8,473	20,854	59,4	0,912	21,766
March 1975	13,121	8,1	10,843	23,964	54,8	2,726	26,690
March 1976	14,313	8,3	14,557	28,869	49,6	3,857	32,727
March 1977	17,610	9,4	18,645	36,255	48,6	4,221	40,476
March 1978	27,087	12,4	23,173	50,260	53,9	5,738	55,999
March 1979	40,125	15,5	26,652	66,777	60,1	7,729	74,507
March 1980	35,322	12,2	28,438	63,760	55,4	8,862	72,622
March 1981	43,070	13,8	34,677	77,747	55,4	10,208	87,955
March 1982	46,543	13,6	44,016	90,559	51,4	11,075	101,634
March 1983	57,516	14,9	54,855	112,371	51,2	16,695	129,066
March 1984	53,113	11,6	54,959	108,072	49,1	14,201	118,595
March 1985	78,972	14,3	59,801	138,773	56,9	13,546	152,319
March 1986	94,516	15,5	74,996	169,512	55,8	18,106	187,618
March 1987	92,726	14,2	93,889	186,615	49,7	23,084	209,699
Note for RWB: Total for 1984 excludes credit of R3,678 x 10^6 withdrawn from funds							
PRETORIA MUNICIPALITY							
June 1975	1,628	7,4	1,497	3,125	52,1	3,517	6,642
June 1976	1,797	7,6	1,831	3,628	49,5	4,586	8,215
June 1977	2,065	8,0	2,061	4,126	50,0	5,852	9,978
June 1978	2,478	8,3	2,226	4,704	52,7	8,075	12,774
June 1979	3,002	8,7	2,492	5,494	54,6	10,059	15,554
June 1980	3,169	11,9	2,920	6,089	52,0	9,541	15,630
June 1981	3,419	8,4	3,404	6,823	50,1	11,836	18,660
June 1982	3,641	8,2	4,230	7,871	46,3	13,715	21,587
June 1983	4,814	9,8	5,275	10,089	47,7	15,863	25,932
June 1984	5,731	10,8	6,447	12,178	47,1	14,789	26,967
June 1985	7,457	11,7	6,779	14,236	52,4	17,503	31,739
June 1986	8,894	12,1	6,931	15,825	56,2	21,589	37,415
June 1987	10,298	12,5	9,099	19,397	53,1	23,776	43,173

Note: Weighted averages of capital charges as a percentage of running costs are as follows:

Rand Water Board 1970 – 1987 : 53,4% (column 6)
Pretoria 1975 – 1987 : 51,1% (column 6)

Vaal River, the effect thereof on the unit costs of water is clearly illustrated by the rates of increase in the unit costs compared with the water demand trends as calculated from the data in Tables 2, 3 and 7 and listed in Table 8 over the period of disruption in supply. Because of annually increasing costs a more direct comparison of unit costs over the period of disruption of supply is not possible and it is evident that a small percentage reduction of the order of 1% in demand will not affect unit costs noticeably.

6.2 From Table 8 it is evident that unit costs of water increased at a much higher rate (26,5% and 27,4%/a for the Rand Water Board and Pretoria respectively) during the two years 1983 to 1985 with their large reduction in water use than before the restrictions of March 1983, when the rates of increase were 12,96% and 14,50%/a respectively. This effect was short-lived, however, and after 1985 the rates of increase in unit costs reverted to about the same as before 1983, viz. 13,75% and 16,63%/a, which are equivalent to 10,08% and 13,83%/a respectively if corrected for the rise in the inflation rate from 12,8% before 1984 to 17,7% during 1985 to 1987. The corrected values are, in fact, lower than those ruling before 1983.

TABLE 7
RAND WATER BOARD AND PRETORIA
UNIT COSTS OF WATER SUPPLIED

Year ending	Unit cost of annual capital charges (Interest redemption, etc.)	Unit cost of annual working costs	Total unit cost for annual operating costs	Unit cost for purchase of water	Total unit cost
	c/m³	c/m³	Average rate of increase over period	c/m³	c/m³
(1)	(2)	(3)	(4)	(5)	(6)
RAND WATER BOARD (Unit costs from Rand Water Board Annual Reports 1985 and 1987)					
March 1970	2,09	1,58	3,64	0,10	3,74
March 1971	1,85	1,63	3,48	0,12	3,60
March 1972	1,90	1,71	3,61	0,14	3,75
March 1973	2,52	1,85	4,37	0,18	4,55
March 1974	2,48	1,69	4,17	0,18	4,35
March 1975	2,43		4,44	0,51	4,95
March 1976	2,43		4,91	0,66	5,57
March 1977	2,85	3,02	5,87	0,69	6,56
March 1978	4,28	3,65	7,93	0,90	8,83
March 1979	5,79	3,85	9,64	1,12	10,76
March 1980	5,23	4,21	9,44	1,31	10,75
March 1981	5,83	4,69	10,52	1,38	11,90
March 1982	5,92	5,60	11,52	1,41	12,93
March 1983	6,73	6,43	13,16	1,96	15,12
March 1984	8,11 +	8,40	16,51	2,17	18,68 +
March 1985	12,54	9,50	22,04	2,15	24,19
March 1986	14,54	11,54	26,08	2,79	28,87
March 1987	13,85	14,01	27,86	3,44	31,30
PRETORIA MUNICIPALITY (Unit costs calculated from data of water supplied to consumers in Table 1 and annual costs in Table 2)					
June 1975	2,20	2,03	4,23	4,76	8,99
June 1976	2,31	2,35	4,66	5,90	10,56
June 1977	2,50	2,50	5,00	7,09	12,09
June 1978	2,88	2,59	5,47	9,40	14,87
June 1979	3,20	2,66	5,86	10,74	16,60
June 1980	3,64	3,35	6,99	10,95	17,94
June 1981	3,51	3,50	7,01	12,15	19,16
June 1982	3,76	4,37	8,13	14,17	22,30
June 1983	4,78	5,21	9,99	15,74	25,73
June 1984	7,42	8,34	15,76	19,13	34,89
June 1985	9,81	8,92	18,73	23,03	41,76
June 1986	11,35	8,85	20,20	27,56	47,76
June 1987	13,20	11,67	24,87	30,48	55,35

TABLE 8
EFFECT OF REDUCTION IN WATER DEMAND AFTER MARCH 1983 ON UNIT COSTS OF WATER

Changes in demand for water supplied to consumers		Rates of increase in unit costs of water	
Period	Water demand trend	Period	Rates of increase in unit costs of water
	RAND WATER BOARD		
March 1973-83	Growth rate 5,78%/a.	March 1972-83	12,96%/a.
March 1983-85	Drop of 22,40% over first year and 26,25% over 2 years	March 1983-85	26,50%/a.
March 1985-87	Growth rate 2,73%/a.	March 1985-87	13,75%/a.
	PRETORIA		
Dec. 1974-82	Growth rate 4,94%/a.	June 1975-83	14,50%/a.
Dec. 1982-84	Drop of 25,6% over first year and 36,29% over 2 years	June 1983-85	27,4%/a.
Dec. 1984-March 1987	Growth rate 5,39%/a.	June 1985-87	16,63%

6.3 The comments in the previous paragraph support the conclusion that for a mature well-developed water supply system a reduction in demand will have the initial effect to increase the unit costs of water supplied but that this effect will be of short duration, probably less than two years, depending on the magnitude and duration of the reduction and whether there is a resumed growth in water demand after the reduction in supply.

6.4 Two cases should be considered when assessing the effect of a reduction in demand.

- A single reduction in demand which will, after the initial tendency to increase costs for a year or two, result in a constant future annual reduction in capital charges for a period related to loan redemption periods. This would apply to the case where a block of flats previously metered in bulk is fitted with individual meters reducing the water supply by about 25% for that block only. This would be such a small proportion of the total supply that there would be no noticeable effect on unit costs for the city as a whole.
- If a policy decision is taken to fit all future blocks of flats with individual meters this would reduce the rate of growth in the total water demand for the city. In turn this would reduce the rate of increase in capital expenditure and thus result in proportionate continued decrease in annual capital charges with a growing relative saving in the cost of as well as in the quantity of water required.

Only the first alternative is considered further. If this proves to be favourable it is obvious that the second will be even more so.

7. Estimate of the reduction in annual capital charges for water due to the saving of water use by individual metering of a block of flats in Pretoria.

7.1 Basis of estimate

It has been shown that in the longer term cumulative capital expenditure is related to water consumption. On the average therefore, the capital expenditure in a given year will be proportional to the increase in water use during that year. A reduction in quantity used (saving) of W in the previous year will, therefore, on the average have the effect of reducing capital expenditure for the year by $\frac{W}{DQ}$ x DR, where DQ is the increase in water use over the year and DR is the capital expenditure for the year which could be expected if no reduction in water use had taken place.

To be comparable with the results of the final project report by the Division of Building Technology to the Water Research Commission the water use and cost data for the financial year 1985/86 as given in para. 1 and in Tables 2 to 5 are accepted. The effect of a reduction of 25% in the use of water for the hypothetical block of 60 flats with individual metering during this and the next two years is calculated for a normal growth period similar to that from 1970 to 1983 with the following parameters:

1. Average use of water
   - For bulk metering : 400 ℓ/d per flat = 8 760 m³/a for 60 flats
   - For individual metering of flats : 300 ℓ/d per flat = 6 570 m³/a for 60 flats
2. Annual saving in water use due to individual metering : 2 190 m³/a
3. Annual saving in water to be purchased from Rand Water Board (Water not accounted for in Pretoria is assumed to be 12% of total supply). : 2 489 m³/a

	Pretoria	Rand Water Board
4. Cumulative capital expenditure up to the financial year ending in 1986	R82,59×10^6	R653,38×10^6
5. Total water supply to consumers during the financial year ending in 1986	77,55×10^6 m^3	653,7×10^6 m^3
6. Rate of growth in water demand (See para. 3).	5%/a	5%/a
7. Rate of increase in cumulative capital expenditure taken as equal to 2,26 times the rate of growth in water demand as for the periods between 1972 to 1984. See Table 5 and para. 2.9 (iii)	11,3%/a	11,3%/a
8. Annual capital charges as a percentage of the cumulative capital expenditure to the end of the previous year (See Table 6 and para. 4.3)	11,8%	13,9%
9. Rate of inflation as for the period 1974 to 1984 (See Table 1 and para. 6.2). The effect of the inflation is incorporated in the ratio of 2,26 referred to in (7) above and is not evaluated separately. See para 2.9 (iii).	12,8%/a	12,8/a
10. Annual capital charges as a percentage of the annual working costs excluding the purchase of water. (See Table 6 and para. 4.2)	52%	52%
11. Purchase cost of water as percentage of the total cost of water supply (See Table 6 and para. 4.4)	59,0%	10,9%

It is considered that the growth rates and percentages derived from the data for Pretoria and the Rand Water Board, although subject to change over the longer term, will be representative of conditions over a relatively short period of up to five years.

7.2 Estimate of the effect of the reduction in demand on annual capital charges

In the following calculations it is assumed that the single reduction in demand, which is small compared to the total city supply, will not lower the base for growth and will simply be a constant reduction below the values which would have obtained if the reduction had not taken place. The calculations for Pretoria are carried out to show single units of expenditure and demand as the differences of large quantities are involved, in order to illustrate the effect on unit costs as well as on the annual capital costs, but this must not lead to a false sense of accuracy. The actual values for the 1985/86 financial year are underlined in the following calculations. All other quantities are based on the parameters listed in section 7.1

Pretoria water supply system

Financial year ending in:	1986	1987	1988	1989
(1) Total water supply to consumers in city during the year				
(a) With bulk metered supply to the block of 60 flats and with a growth rate of 5%/a.	77 546 626 m^3	81 423 957 m^3	85 495 155 m^3	89 769 913 m^3
(b) With a reduction of 2 190 m^3 in 1986 due to individual metering of the block of 60 flats	77 544 436 m^3	81 421 767 m^3	85 492 965 m^3	89 767 723 m^3

Financial year ending in:	1985	1986	1987	1988	1989
(2) Increase in water supply to consumers in city over that for the previous year.			3 877 331 m^3	4 071 197 m^3	4 274 758 m^3
(3) Reduction in water use of 2 190 m^3 during 1986 for the block of flats as a proportion of the normal increase in consumption of the city during 1987	–		$\frac{1}{1\ 770}$	–	–
(4) Capital expenditure					
(a) With block of flats bulk metered i.e. no reduction in demand for water: –					
(i) Cumulative capital expenditure to the end of the financial year with a rate of increase of 11,3%/a.	R82 590 000		R 91 922 670	R102 309 932	R113 870 954
(ii) Capital expenditure during the year	R9 296 558		R9 332 670	R10 387 262	R11 561 022
(b) With block of flats individually metered and reduction in water use of 2 190 m^3/a in 1986: –					
(i) Proportional reduction in capital expenditure for 1987 due to the reduction in water demand in 1986 $\frac{1}{1\ 770}$ x 9 332 670:-	–		R5 273	–	–
(ii) Reduced capital expenditure during 1987	–		R9 327 397	–	–
(iii) Cumulative capital expenditure to the end of the financial year allowing for reduced expenditure in 1987	R82 590 000		R91 917 397	R102 304 659	R113 845 681
(5) Annual capital charges at 11,8% of cumulative capital expenditure to end of previous year: –					
(a) For bulk-metered block of flats (no reduction in demand) 4(a)(i)×0,118:	R8 894 392		R9 745 620	R10 846 875	R12 072 572
(b) For individually metered block of flats 4(b)(iii)×0,118:	R8 894 392		R9 745 620	R10 846 253	R12 071 950
(6) Reduction in annual capital charges due to individual metering of block of 60 flats: 5(a) – 5(b)	–		–	R622	R622
(7) Unit cost of annual capital charges:					
(a) With bulk-metered flats $\frac{5(a)}{1(a)}$	11,46973c/m^3		11,96898c/m^3	12,68712c/m^3	13,44835c/m^3
(b) With individually metered flats $\frac{5(b)}{1(b)}$	11,47006c/m^3		11,96931c/m^3	12,68672c/m^3	13,44800c/m^3

Financial year ending in:	1985	1986	1987	1988	1989
(8) Total water supplied to consumers with growth rate of 5%/a. ($\times 10^6 m^3$)	662,57	653,700	686,385 (Actual value 664,4 with continued restrictions)	720,704	756,739
(9) Increase in total water supply over that for previous year with growth rate of 5%/a. ($\times 10^6 m^3$)		31,129	32,658	34,319	36,035
(10) Cumulative capital expenditure to end of financial year with rate of increase 11,3%/a. ($R10^6$)		653,38	727,21	809,39	800,84
(11) Capital expenditure during year ($R10^6$)		43,53	73,83 (Actual value 71,15)	82,17	91,46
(12) Saving of 2 489 m^3 of water use for block of flats in Pretoria in 1986 as a proportion of the increase in consumption for the year 1987		$\frac{1}{12\ 507}$	$\frac{1}{13\ 132}$	–	–
(13) Proportional reduction in capital expenditure during 1987 due to the saving in water consumption by the block of flats in 1986 $\frac{1}{13\ 132} \times 73,83$ ($R10^6$)			R5 622		
(14) Reduction in annual capital charges in the years after that in which the reduction in capital expenditure takes place at 13,9% of the reduction in capital expenditure		–	–	R781	R781

8. Conclusions

From items (7) and (14) of the calculation in the previous section it is concluded that the reduction of 25% in water use due to the individual metering of a block of 60 flats in Pretoria during 1986 would lead to a reduction in annual capital charges for water supply of R622 + R781 = R1 403/a during 1988 and thereafter. This is substantially higher than the increased cost of R339/a on annual operating costs only referred to in para. 1. The net result is that, if allowance is made for the effect of a reduction in water use on capital expenditure, the individual metering of the block of 60 flats in Pretoria would, after about 2 years, lead to a reduction in overall costs of R1 064/a, i.e. of about 24% in the cost of supplying water for the same flats if they are metered in bulk.

Because of the approximations made, the fact that the relation between capital expenditure and water supply varies from year to year and the effects of inflation, the benefits of the individual metering will not be clearly defined in accounts. It is believed, however, that this analysis illustrates that the provision of individual metering to flats is economically beneficial if overall costs are taken into account.

The unit cost figures in items 7(a) and 7(b) of the calculation confirm the statement in para. 6.1 that a small percentage reduction in demand will not have a noticeable effect on unit costs. The unit costs for annual capital charges do in fact show a slight increase in the year after that, but when the effect of the corresponding reduction in capital expenditure on annual capital charges becomes effective after two years with a continued growth in demand, the calculated values in fact show a slight decrease in the unit cost in subsequent years compared to the position if the decrease in demand did not occur.

Although the relationship between costs and water supply will vary for different centres, it appears to be likely that metering of all consumers will finally be beneficial not only for reducing the quantity of water required but also for reducing the cost of water supply to consumers.

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