WATER RESEARCH COMMISSION

Botshabelo:

Case study of water supply and sanitation arrangements.

SUPPORTING DOCUMENT TO REPORT KV 73/95

Working paper prepared as part of a project titled:

Evaluation of Water Supply to Developing Urban Communities

May 1994

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Preface

The Water Research Commission appointed Palmer Development Group to carry out an evaluation of water supply to developing urban communities in South Africa in May 1992.

The broad objective of this project is: to carry out a strategic evaluation of the present status of domestic water supply to developing communities in the urban areas of South Africa with a view to providing relevant and up to date information and analysis upon which rational policy and practice may be based so that the large and increasing demand for basic water supply services in developing urban communities may be met in an economically efficient and equitable manner.

The project was conceptually divided into three phases as follows:

Phase 1: Overview

a. A review of the current status with water supply to developing areas internationally.

b. Execution of a survey of water supply to the urban areas of South Africa, based on questionnaires and interviews, to determine who has access to adequate water supply, what type of systems are being used, and to obtain as much operating and cost information as possible.

Phase 2: Evaluation

a. Evaluation of water supply systems from the point of view of: level of access and acceptance by communities; technical options; cost; financial viability; management efficiency; and environmental impact. The method of evaluation was largely based on a case study approach.

Phase 3: Proposals

a. Putting forward proposals for improving water supply in these developing urban areas over the next decade.

b. Preparation of guidelines for the planning and implementation of water supply systems.

A comprehensive set of reports has been prepared for each phase of the project, as listed on the following page.

This report is one of the set of case studies which has been carried out to get a more in-depth understanding of the factors affecting water supply in South Africa, with an orientation as described below.

Orientation of case studies

The intention has been to select case studies to cover a wide variety of water supply situations, from those in metropolitan areas to those in "dense settlements" which are remote but still considered to be functionally urban. In each case specific factors of importance were identified. The findings from each case study have been drawn together in the summary report (Report No 20) where they are used to develop overall proposals for improving water supply services in South Africa.

It is important to note that the case studies are not intended to be used as a basis for planning water supplies in the particular areas studied.

List of documents

PHASE 1

1 Main Report: Evaluation of Water Supply to Developing Urban Communities in South Africa

Regional profiles: Domestic Water Supply : Regions A - J

2 Region A: Western Cape
3 Region B: Northern Cape
4 Region C: Orange Free State, including QwaQwa and part of Bophuthatswana
5 Region D: Eastern Cape, Ciskei and portion of Transvaal
6 Region E: Natal / Kwazulu
7 Region F: Eastern Transvaal
8 Region G: Transvaal, Gazankulu, Lebowa and Venda
9 Region H: PWV and the Adjacent Areas of KwaNdebele and Bophuthatswana
10 Region J: Western Transvaal including Bophuthatswana

Bulk Water Supply to Metropolitan Areas

11 Bloemfontein
12 Cape Town
13 Port Elizabeth

PHASE 2

14 **Ikapa:** Case study of a water supply system in a metroploitan area.
15 **Mamelodi:** Case study of a water supply system in a metropolitan area.
16 **Botshabelo:** Case study of water supply and sanitation arrangements.
17 **Inanda:** Case study of water supply arrangements to a peri-urban area.
18 **Winterveld:** Case study of informal water supply arrangements.
19 **Lebowa:** Case study of water supply in dense settlements.

PHASE 3

20 **Main report: Evaluation of water supply to developing urban communities: summary**

21 Costing of water supply arrangements.
22 Water and sanitation handbook for communities.
23 Guidelines for the provision of water supplies to developing urban communities (Still to be prepared).

Acknowledgements

The research in this report emanated from a project funded by the Water Research Commission and entitled:

"*Technical, socio-economic and environmental evaluation of water supply to* developing urban areas in South Africa".

The Steering Committee for this project included the following people:

HC Chapman	Water Research Commission (Chairman)
BM Jackson	Development Bank of Southern Africa
C Croeser	PLANACT
C Sweigers	Department of Water Affairs
B Myrdal	Development Action Group
M van Ryneveld	University of the Witwatersrand
JP Rodrigues	Municipality of Durban
S van der Merwe	Rand Water Board
A Fourie	Cape Provincial Administration

The financing of the project by the Water Research Commission and the contribution of the members of the Steering Committee is gratefully acknowledged.

The information upon which this document is based was obtained from a range of persons and organisations whose assistance is sincerely appreciated (see list of interviews at the back of the document).

Project team

This document has been written by Ernst Zöllner of Palmer Development Group, Cape Town. Ian Palmer and Rolfe Eberhard assisted with editing and the drawing of conclusions. Frances Cullinan (edits), Trevor Hughes (graphs), Lynette Booyens (maps and figures) and Meta Zöllner *(cover page) provided technical assistance.*

Summary

Botshabelo is a formal township located 55 km east of Bloemfontein. The primary aim of its politically-motivated creation by the state in 1978, was to direct resettled black communities of the Eastern Free State away from Bloemfontein. As the laws and policies which encouraged industries and forced people to Botshabelo fell away after 1986, the growth of the city slowed down considerably and has stabilised in recent years.

Water and sanitation systems vary between the residential blocks. The higher income area (known as block 'H') is fully reticulated, and the rest of the settlement is supplied through standpipes in the streets at varying standards. Buckets, pit latrines and conservancy tanks are used as sanitation options in these areas.

Issues in the supply of water include: problems with the design of the internal bulk system; inadequate water provision in some residential areas; high water losses; and a lack of cost recovery, which requires substantial subsidisation by the state. Tariffs and levies charged for water would have to increase substantially in order to reduce dependence on state funding.

Various problems are associated with each of the sanitation systems, but the operating problems of the bucket system and the overflowing of pit latrines have received wide public attention. Concern about bacterial and phosphate pollution in the upper Modder River system into which Botshabelo discharges its effluent has been expressed by consultants and researchers.

Consultants have made extensive proposals on how to address the problems in the water and sanitation systems. Due to continued day-to-day crisis management in the town, official reaction to such proposals has been limited. Most parties, including the effectively voiceless community, argue that the introduction of waterborne sanitation in the whole settlement would address the health and pollution problems in the city. However, this proposal is problematic in many regards; most notably it may worsen the financial deficits relating to both water and sanitation supply. It will also not resolve the phosphate pollution problem. A more creative approach to the problems of the water and sanitation supply is urgently required.

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1. INTRODUCTION

1.1 Objectives of the case study

Water distribution and sanitation systems are most commonly linked through waterborne transport of excreta. This form of sanitation provides a high level of convenience, but the subsequent disposal of excreta and polluted water is always costly. It also requires a reliable and sufficient supply of water on the site of the toilet structure, an option often inappropriate to local economic, social and water-resource conditions of developing urban areas in South Africa.

This case study of Botshabelo, a large formal township east of Bloemfontein, highlights this linkage between the two systems and particularly how decisions about the future of the sanitation system affects capital, operation and maintenance requirements of water distribution. The case study highlights pertinent questions about the level of services which communities should have access to, given a lack of local financially sustainable systems, or a failure of such systems. The inherent danger of reactionary management decisions leading to the implementation of supply systems which would require substantial subsidisation is illustrated.

1.2 Structure of the document

Section 2 of the document presents the major settlement characteristics, which provides background to a discussion of the current water and waste services in Section 3. Proposals for addressing current problems with water and waste services are discussed in Section 4, with conclusions and lessons to be learnt , dealt with in Section 5.

2. BACKGROUND TO BOTSHABELO

2.1 A brief history

The transformation of empty veld south of the Bloemfontein-Thaba Nchu Road on the plains east of Bloemfontein into a large city within a decade was the most significant urban development in the Free State since the growth of the OFS Gold Fields in the 1950's (see Figure I). Within five years of the first community being settled in Botshabelo in 1978, the township grew into a vast, sprawling township with a population of 150 000 (De Vos 1992).

The construction of this city 'in the middle of nowhere' is similar to the creation of Atlantis north of Cape Town during the same period, with the following common characteristics:

- the political doctrine of 'separate development' was the sole reason for their creation and continued existence[1];
- they were to act as 'counter-poles' to the core city, supporting policies of halting growth in the black population of Bloemfontein and limiting growth of the Coloured population in Cape Town; and
- displaced farm workers and their families were to be accommodated in these towns as well as communities forcefully removed from 'black spots' in surrounding areas.

Resettled communities from Thaba Nchu, Bloemfontein and other Free State towns and displaced farms workers and their families very rapidly swelled the population at Botshabelo ('place of refuge'), administered between 1978 and 1992 by the Department of Development Coordination (later Development Aid). As with Atlantis, the state invested generously in infrastructure, housing and industrial location incentives to support the artificial creation of the settlement.

Because of greater control by the state over the location of black households, the growth of Botshabelo was more in line with planning predictions than the slow development of Atlantis. Botshabelo in fact grew much too fast, outstripping the capacity of the state to provide services and housing in the otherwise 'model' township development (see Figure II) (Krige, 1987)[2]. As in Atlantis, generous decentralisation incentives attracted numerous industries, and at its peak Botshabelo had 140 factories employing 10 000 workers (Prisma, 1990).

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[1] The political-economy of the decision to create Botshabelo is described well in Krige (1987, 1990); Murray (1987); and Coetzee (1988).

[2] Due to the shortage of serviced sites, families could only find shelter as sub-tenants, and in September 1985 there were 2.3 families per site or 30% 'over-population' in especially blocks A-E. When the overcrowding reached a critical point in November 1985 some 10 000 families, mostly backyard squatters from blocks A-E, occupied blocks L, M and T which had already been surveyed for sites. Officials did not resist the occupation and reacted by speeding up installation of basic infrastructure and minor resettlement took place.

Figure I: The Bloemfontein-Botshabelo region

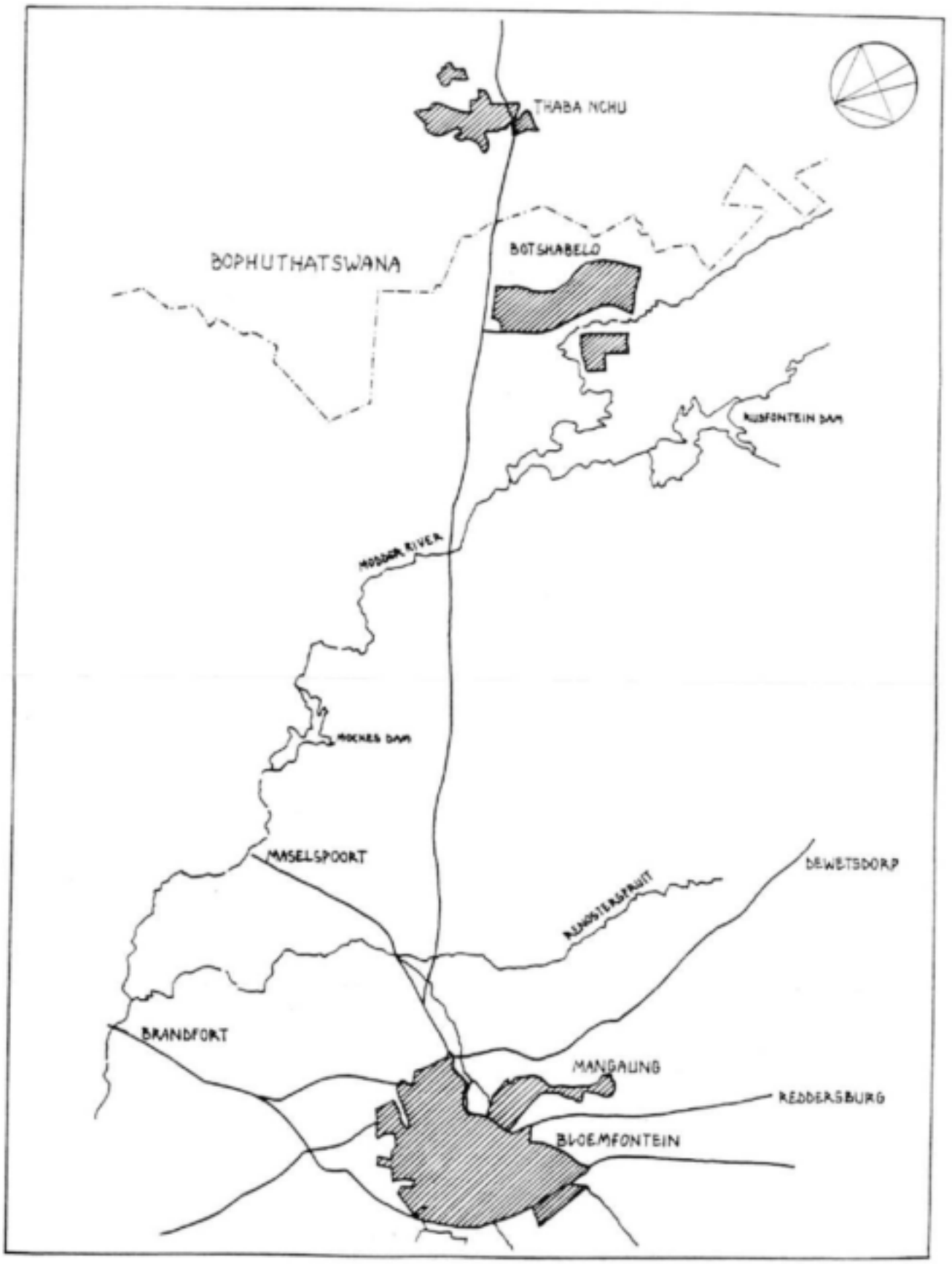
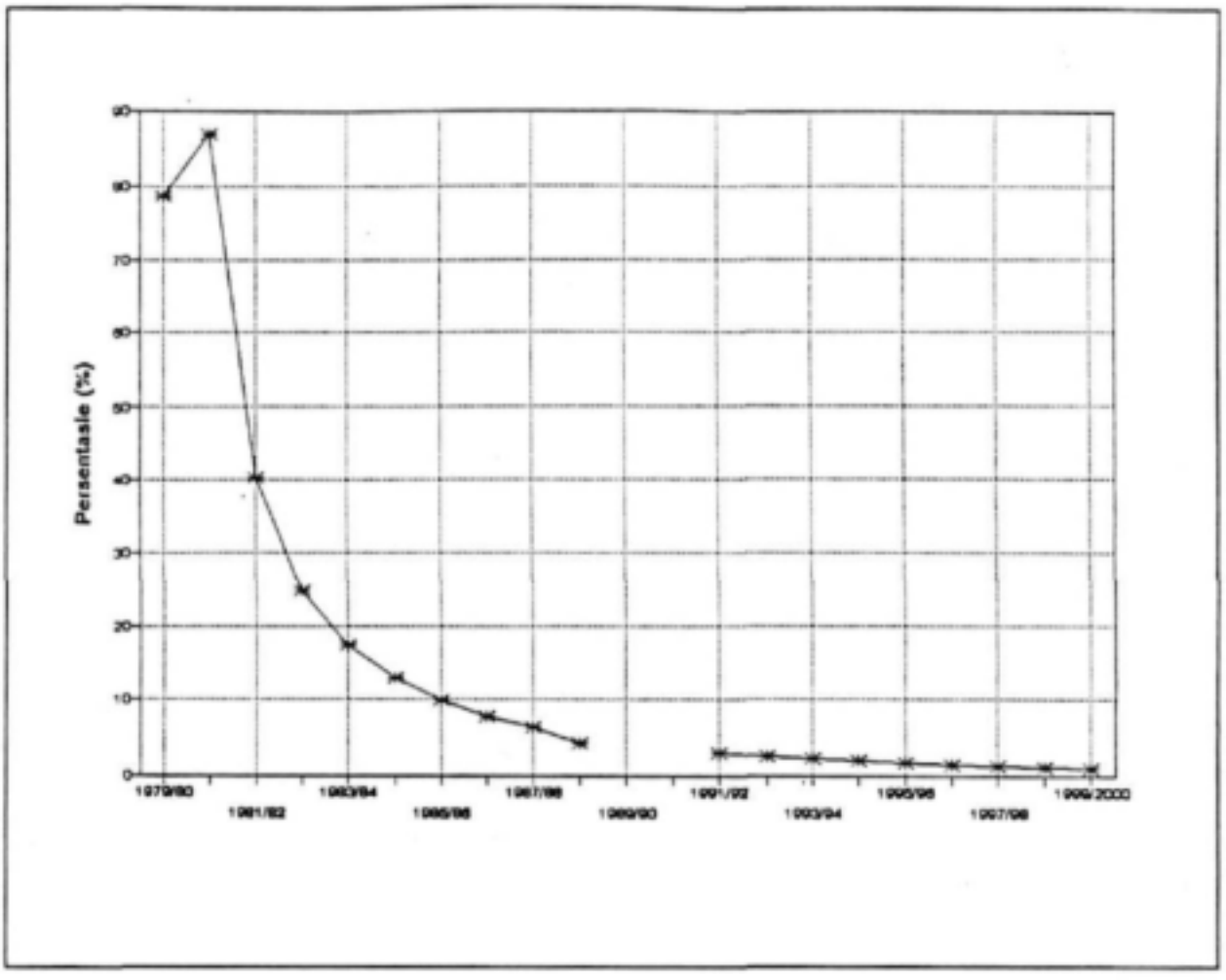


Figure II: Yearly population growth rate, Botshabelo 1980-2000



Botshabelo was a 'pet project' of the former Department of Development Aid (DDA) (Murray, 1988), who described it as "*an attractive town with a totally different appearance than other black cities*" (Spies quoted in Krige, 1990). Considerable time was invested in planning and monitoring this 'New Town' development, making it even today one of the townships with the best information database on most social matters. Botshabelo never became a local authority in terms of Act 102 of 1982 and, with the demise of DDA, the management of the area was handed over to the Provincial Administration of the Orange Free State (PAO) in May 1992.

In 1985 it was predicted that Botshabelo would have a population close to 1 million by 1995, a similar order of magnitude as predicted for Atlantis in 1978. But these predictions proved to be exaggerated. As the laws and regulations which made the creation of these settlements

possible fell away one by one (starting in 1986 with the scrapping of Influx Control measures) the basis on which these settlements were founded collapsed:

- Botshabelo's population has stagnated over the last three years and is currently estimated to be 220 000[3]; and
- with the removal of decentralisation incentives, many factories closed down or relocated to the core cities, leading to large-scale retrenchments and rising unemployment (Van der Merwe et al, 1992).

In the light of this, questions have recently been asked about the future of Botshabelo: should it be allowed to decline, to be neglected as an urban settlement which should never have been built? Or should it be maintained and consolidated in the light of the considerable resources which have gone into its construction?

2.2 *Settlement structure*

a) The block alphabet

A particular characteristic of Botshabelo is its residential 'blocks': the town was designed to consist of cellular blocks with their own commercial centres and public facilities (see Figure III). These residential blocks were given the names of letters in the alphabet, and there are currently are 18 such distinct areas which form the basis for the planning and administering of services.

The first areas to be developed were those furthest from the Bloemfontein-Thaba Nchu Road, namely blocks A, B, C, D, and E. Despite the formal planning on which the development of the city was based, the dominance of informal housing structures gave it an initial appearance of an informal settlement. Through upgrading and increased private building activity in the mid-1980's, informal structures declined to 54% of the 37 000 units in 1985 and to 40% of the housing stock in May 1992 (Krige, 1990). Estimates of stand numbers in 1992 are given in Table 1. The large number of vacant sites is an indication of to what extent growth of the city has stagnated in recent years. Current gross densities are between 5.6-10.3 DU/Ha, with erven varying in size between 160-600 m^2 (De Vos, 1992).

[3] The migration patterns of the Botshabelo population are described in Van der Merwe et al (1992). Population growth rates have declined from 8.52% in 1988 to 1.74% in 1991, and is expected to be 0.62% in 2000, well below national urban growth rates.

Table 1: Population and housing units per residential block

BLOCK	OCCUPIED FORMAL STANDS	VACANT FORMALS TANDS	INFORMAL HOUSING UNITS	BACKYARD SHACKS	TOTAL STRUCTURES	POPULATION
A	2 354	0	0	550	2 904	13 276
B	878	0	173	220	1 271	4 952
C	2 732	0	121	270	3 123	15 408
D	2 130	0	10	440	2 580	12 013
E	1 973	0	11	547	2 531	11 128
F	2 026	1 010	169	68	2 263	5 713
G	1 254	0	288	350	1 892	7 073
H	3 086	0	0	10	3 096	17 406
J	2 726	0	396	848	3 970	15 376
K	2 962	0	419	451	3 832	16 706
L	2 559	0	0	114	2 673	14 433
M	2 941	0	0	125	3 066	16 587
N	2 079	1 381	0	81	2 160	11 730
S	750	603	0	0	750	3 682
T	1 900	0	0	96	1 996	16 864
U	3 865	0	0	113	3 978	21 800
W	3 297	0	0	108	3 406	18 596
TOTAL	39 512	2 994	1 587	4 390	45 489	222 739

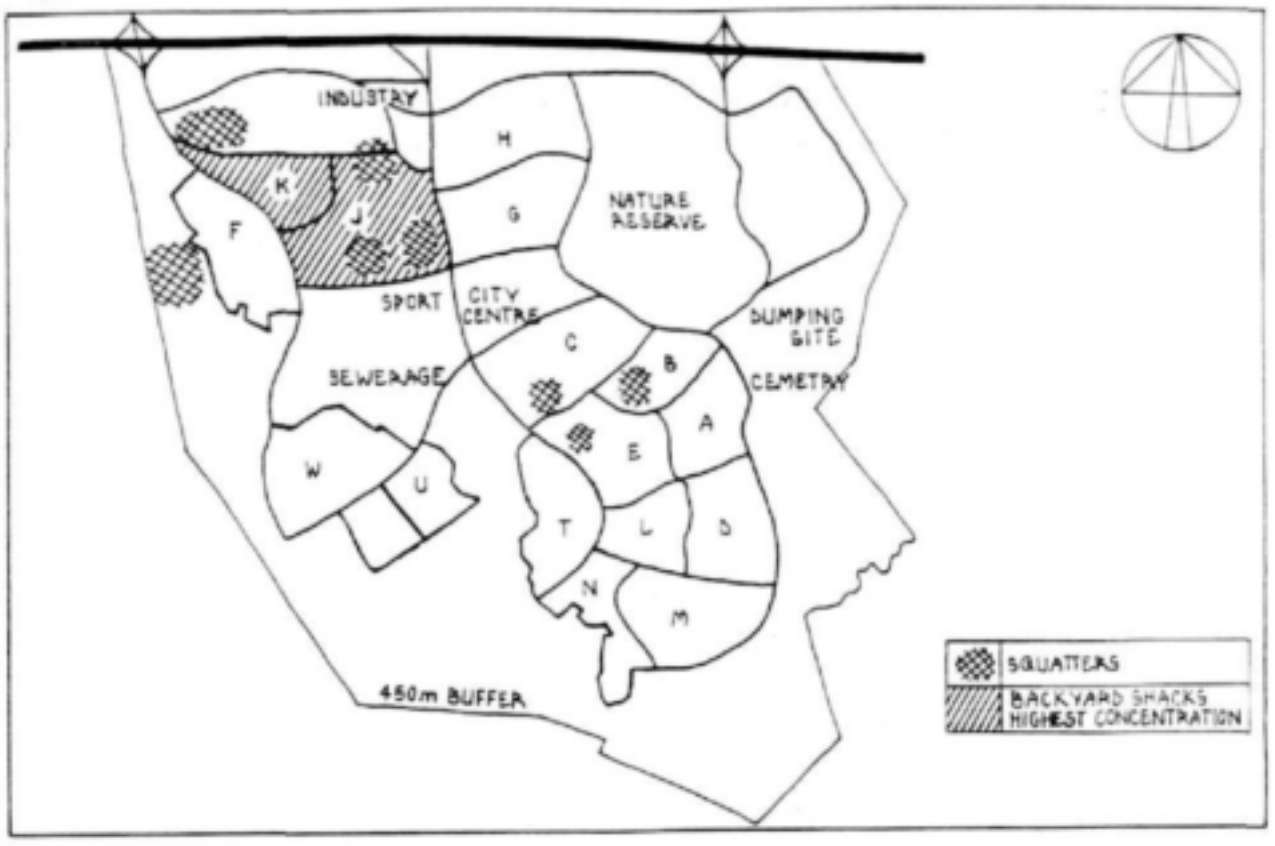
Status: May 1992
Sources: compiled from Van Wyk & Louw (1993) and official Town Council figures

Section H was developed as an 'elite' or higher income area, with larger plots sizes and fully reticulated services. It also has an advantageous location close to the city centre, industrial area, nature reserve and the very important Bloemfontein-Thaba Nchu Road.

b) Consolidation and densification

Despite the large number of vacant serviced sites in the south of the settlement, there are currently about 1 500 squatter units in various pockets in the north of the settlement (see Figure III). There are also more backyard shacks in these northern areas (mainly block J next to the industrial area), reflecting the desire of households to live as close as possible to the

Figure III: The residential structure of Botshabelo



industrial area, town centre and the Bloemfontein Road[4]. Authorities have recognised the need for a more compact city to reduce travel and servicing costs and selective infill development is planned on land left open for medium to long-term development of education and sport facilities.

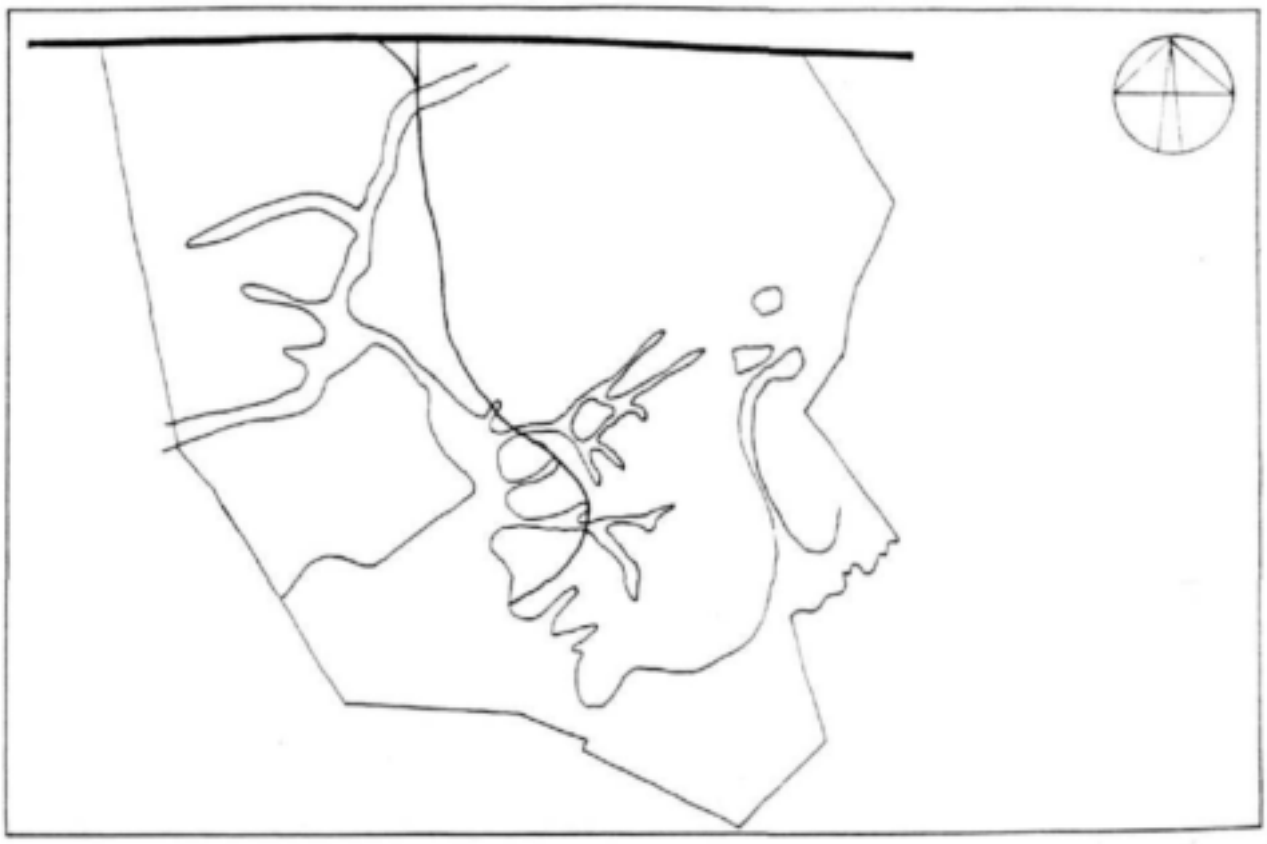
c) River and stormwater system

Botshabelo is characterised by an extensive system of open spaces which fall within the 50-year flood line. Stormwater from these open spaces flows into the intermittently flowing Klein Modder River, which divides Botshabelo into two distinct parts, with blocks W and U connected to the rest of the settlement via two bridges (see Figure IV).

The Klein Modder joins the Modder River below the Rustfontein Dam from where it flows into Mockes Dam (see Figure V). Below Mockes Dam is the Maselspoort weir and the Krugersdriftdam.

[4] By living in the north of the city, households can save R2.00 per day in taxi and bus fees for travel from south to north (or savings of R40 per month).

Figure IV: The flood plain system within Botshabelo

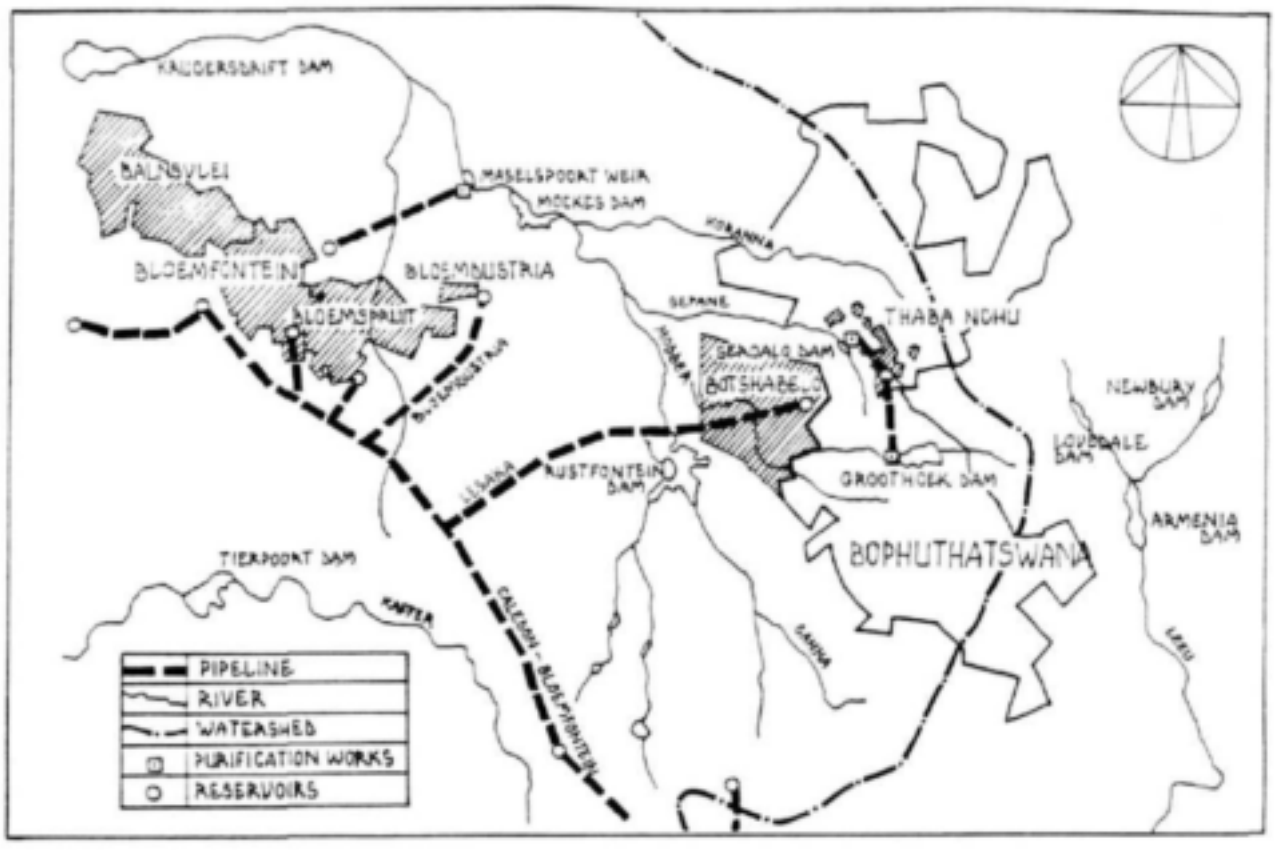


2.3 Living in Botshabelo

Botshabelo's population is largely dependent for its income on employment and remittances from outside the area: 66% of the workforce migrate on a daily, weekly or monthly basis to places of employment outside Botshabelo (51% of migrants work in Bloemfontein and 31% in the OFS Gold Fields). The extensive surveys by the Institute of Socio-economic Research (ISEN) showed that:

- unemployment was 22% in 1991 (15% in 1988) (Van der Merwe et al, 1992);
- 1.8% of the population had matric or a higher level of education in 1988 (Van der Merwe et al, 1992);
- average monthly incomes in 1991 were R 771 (R 523 in 1988) per household, or R 136 (R 101) per person (Van der Merwe et al, 1992); and
- average household sizes were 4.6 persons, and average number of persons per stand slightly higher at 4.9 (including the backyard shack dwellers).

Figure V: The Modder River system and bulk water supply to Bloemfontein-Botshabelo



Botshabelo is described by Krige (1988) as:

"a concentration of socio-economic problems in the OFS caused by the resettlement mentality, the impact of the urbanisation process on dislocated farm workers and their families[5]*, and also a dormitory mentality".*

[5] Coetzee (1988) argues that the vast majority of inhabitants of Botshabelo come from rural areas and therefore have a rural inclination that is not compatible with the demands of urban life.

3. WATER AND SANITATION SYSTEMS

3.1 Water supply

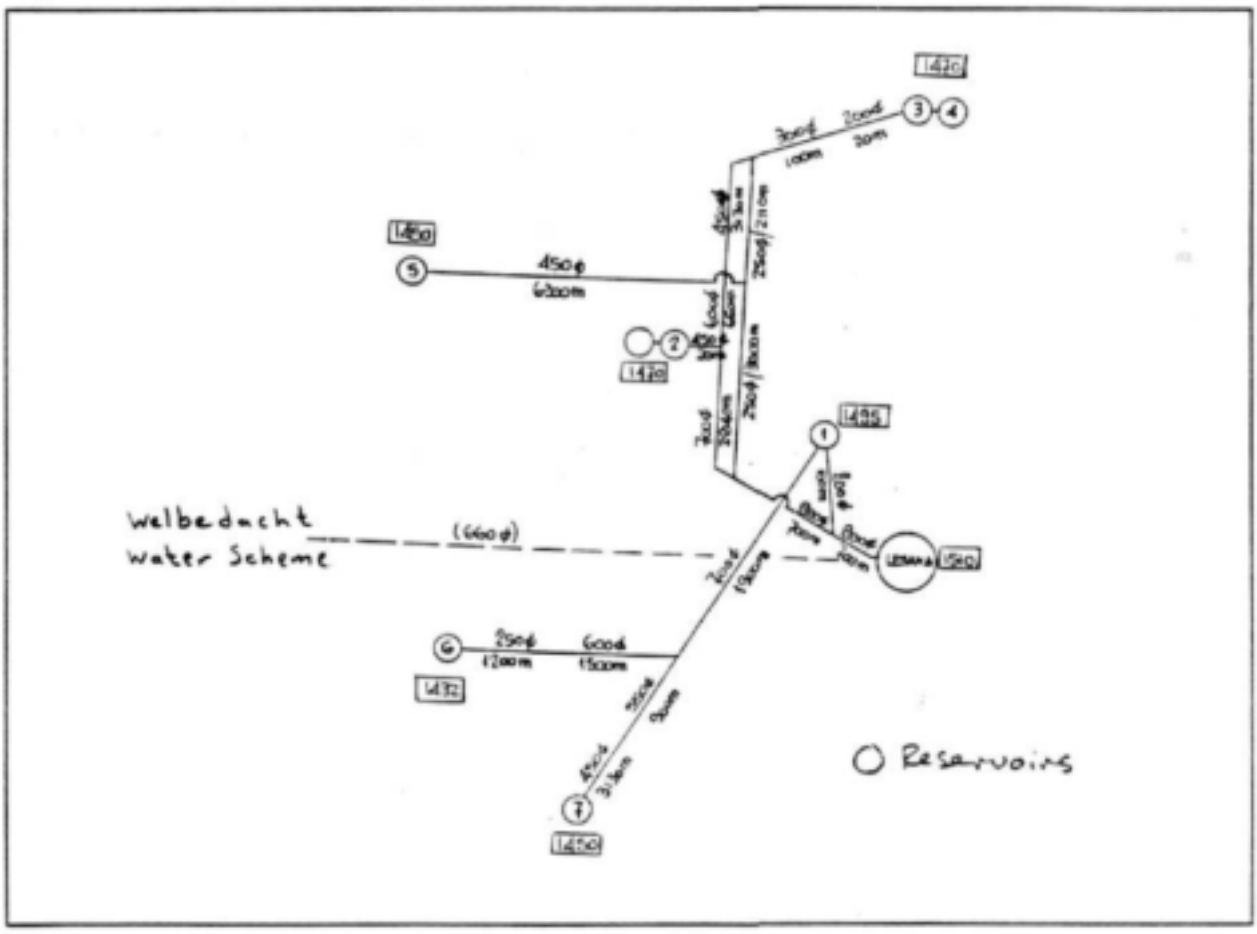
a) Bulk

Lesaka water scheme

Bulk water is supplied to Botshabelo by the Board of Bloem Water from the Welbedacht scheme. A high pressure pump station, part of the Welbedacht scheme, supplies up to 30 000m³/day through a 1 170 mm concrete pipeline and a 600 mm diameter steel pipeline to the four Lesaka reservoirs at Botshabelo. These have a capacity of 52Ml. Botshabelo's position in relation to Bloem Water's bulk scheme is shown on Figure V.

There are seven secondary reservoirs in the various residential blocks with a joint capacity of 27,5 Ml. Figure VI from the water master plan (Van Wyk & Louw, 1993) shows the secondary reservoirs and pipe connections.

Figure VI: Diagrammatic layout of secondary reservoirs and pipes



Bulk water use

Bulk water sales to Botshabelo are shown in Table 2. The sharp increase in water usage in the last two years is attributed to expanded reticulation and increased water losses.

Table 2 : Bulk water sales to Botshabelo

YEAR	TOTAL (Kl)	ADC (Kl)	HMF (Kl)	ADC/HMF	% YEAR ON YEAR INCREASE
1989	3 022 626	9 160	21 320	2.33	-
1991	4 131 175	11 475	18 372	1.60	25.3
1992	5 238 308	16 322	20 715	1.27	42.2

ADC - Average daily consumption; HMF - Highest monthly flow
Source: Van Wyk & Louw (1993)

Bulk water tariff

Bloem Water charges Botshabelo 86c/kl, which includes a 4c levy as contribution to a capital development fund payable by all bulk users. Bloem Water sells water to Bloemfontein Municipality at a sliding scale: the greater the consumption, the lower the price. Based on current estimates, the price for Bloemfontein is expected to be 70c/kl. The 16c difference in bulk water costs between Botshabelo and Bloemfontein is attributed to higher capital redemption and operating costs on the Lesaka scheme (see Table 3)[6].

Table 3: Bulk water tariffs charged by Board of Bloem Water

URBAN AREA	WATER SOLD (Ml/year)	PRICE/COST (c/kl)
Botshabelo	3 390	86c
Bloemfontein	24 730	70c
Mangaung	5 370	70c
Other consumers	4 610	57c
TOTAL	38 100	average: 70c

Source: Board of Bloem Water Annual report 1992/93, estimates for 1993/94

[6] Bloem Water aims towards equal bulk tariffs within its supply region within 5 years. Bulk tariffs to Botshabelo are expected to remain at its present level (or even decline slightly) within this period, whereas the tariff charged to smaller consumers is expected to increase substantially.

b) Reticulation

Extent of reticulation

The higher income area (block H), the industrial area and the town centre are fully reticulated, as are primary and secondary schools in other areas. The rest of the settlement is supplied through public standpipes in the streets with between 15 and 56 households per standpipe[7].

Table 4: Number of standpipes per block

BLOCKS	HOUSE-HOLDS (A)	No OF STAND-PIPES (B)	(A/B)	No OF NON-OPERATING STANDPIPES
A	2 904	93	31	3
B	1 271	43	30	3
C	3 123	138	23	10
D	2 580	84	31	4
E	2 531	93	27	3
F	1 220	63	19	1
G	1 892	96	20	3
J	3 967	175	23	22
K	3 832	135	28	12
L	2 673	48	56	1
M	3 066	53	58	1
N	2 160	104	21	0
S	750	50	15	0
T	1 900	47	40	0
U	3 978	140	28	0
W	3 310	102	32	1
	41 157	1 464	28	64

Status: February 1992

Domestic water consumption

There are approximately 38 500 official customers in the water distribution system. Water consumption is only metered at 2 198 of these connections (5.7%) to whom monthly accounts

[7] In these areas households can obtain yard connections at own cost, but very few such connections have been made.

are rendered. These metered connections are located in area H (1 378), area B (50), area N (50) and the industrial and commercial areas (720). The remainder of municipal and residential users are not metered.

Average daily water use per person is shown in Table 5. Although the table is based on very approximate "order of magnitude figures", it can be seen that:

- per capita water consumption in Botshabelo is around 15% of that in Bloemfontein; and
- within the Bloemfontein-Botshabelo-Thaba Nchu region, Botshabelo and Mangaung combined have 65% of the population but use only 27% of the bulk water supply.

Table 5: Per capita water consumption in the Bloemfontein region

TOWN/CITY	POPULATION	Ml/day (1993/94 estimate)	% loss	% domestic	l/cap/day (ex dom)
Botshabelo	220 000	14.84	20	95	51
Bloemfontein	140 000	87.28	7	60	330
Mangaung	155 000	18.35	10	87	91
Thaba Nchu	65 000	2.50	15	100	33
TOTAL	580 000	122.97	-	-	-

Based on estimates form various sources

Domestic water tariffs

The following water tariffs apply in Botshabelo (1993/94):

- Where water is metered, a tariff of 90c/kl applies.
- Households with yard taps are charged a flat monthly levy of R7.20
- Households in areas with public standpipes are required to pay R2.40 per month.

c) Issues in water supply

Design of bulk system

Board of Bloem Water finds the considerable variation in flow tempo to the Lesaka reservoirs problematic (see Table 2) due to the high energy costs of continuous pumping. Van Wyk and Louw (1992a) infer that the Board requires that bulk infrastructure at Botshabelo be upgraded

through additional secondary storage capacity to allow for a peak flow factor (PFF) of 1.25 to 1.35.

Inadequate service provision

Table 6 shows the levels of access to water in various parts of Botshabelo. Areas of particular concern are Blocks L, M and T where there is not a sufficient number of standpipes and access inadequate, based on the assumption that one standpipe to 25 households represents an adequate service (in Block M there are an average of 56 households per standpipe).

Table 6: Access to water supply

Level of access	Population	%	Blocks
House/yard connection	17 000	8	H
Public standpipes (>1 per 25 households)	71 000	32	C,F,G,J,N,S
(<1 per 25 households)	89 000	40	A,B,D,E,K,U,W
(<1 per 50 households)	43 000	20	L,M,T
TOTAL	220 000	100	

Source: own estimate

High water losses

The lack of metering of private and public water users makes an accurate estimate of water losses impossible, but a sharp increase in bulk water consumption in the absence of any significant increase in population indicates that losses on the network are increasing - currently estimated at 20%. The main source of water losses are pipe bursts within residential areas. A maintenance teams is engaged with repair work for a large percentage of working days per month[8]. No water loss management programme is currently in place, partly due to the shortage of technicians and engineers[9].

Lack of cost recovery

Water and sanitation systems are not accounted for separately at present: personnel, vehicle maintenance costs and income from levies and accounts paid are not ascribed to specific

[8] Personal communication, Gerhard van der Merwe, Botshabelo Town Council.

[9] Existing vacancies for technical personnel can not be filled due to a lack of applications or interest.

trading activities. Table 7 is an attempt to present income and expenditure statement for water trading based on various estimates and information collected. It should therefore be regarded as an order of magnitude estimate only.

Table 7: Operating, maintenance and capital budget, 1993/94

ITEM	1993/94 ALLOCATION/ ESTIMATE (R '000)	SOURCE
Bulk purchases	4 419	Van Wyk & Louw (1993) estimate
Operation and maintenance	1 700	City Engineer & own estimate
Capital projects	4 000	City Treasurer's budget, 1993/94 Includes interest redemption and new capital projects
TOTAL EXPENDITURE	10 119	
Income from water sales	1 341	Based on April-Sept 1993 sales income
ESTIMATED SHORTFALL	8 778	

- The estimated shortfall for 1993/94 would be approximately R 8.78 million (or 86% of total expenditure of R10 million).

- Income for the sale of water (R1.34 million) currently does not even cover the O&M budget of R 1,7 million per year.

The reasons for such gross under-recovery are explained in Table 8. If all consumers were to pay the monthly levies or the tariff applicable in Botshabelo, revenue from water sales would amount to approximately 25% of total expenditure. However, revenue received is currently only 50% of that which is due in terms of current levies and tariffs (or 13.78% of total expenditure)[10]. Levies and tariffs are set at a level which would not even raise half the amount needed for the operation of the system (should everybody pay).

Complex water tariffs

Table 9 compares the unit water cost and retail to bulk tariff ratios of Botshabelo to other cities in the region and elsewhere.

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[10] According to Mr T. Africa, Botshabelo, between 1 April and 30 September 1993 R 670 532.55 was collected in water levies and account payments. This is 13.78% of the required amount to cover expenditure.

Table 8: Average costs and revenue

ITEM	1993/94 ESTIMATE R/kl	1993/94 ESTIMATE R/person	NOTE
O&M costs (including bulk purchases)	1.21	27.81	See tables 2 and 7 for bulk purchases and financial estimates
Total expenditure	2.00	46.00	
Revenue due (based on current levies/ tariffs)	0.54	12.43	
Actual revenue received	0.27	6.10	

Table 9: Comparison of unit water costs and retail to bulk tariff ratios

TYPE OF WATER SUPPLY		DOMESTIC TARIFF at an assumed monthly household consumption of 3.2kl	RATIO OF RETAIL TARIFF TO BULK TARIFF IN THE AREA
On-site connections	Botshabelo - metered	R 0.90 per kl	1.03
	Botshabelo - unmetered	R 2.25 per kl	2.57
	City of Bloemfontein	R 1.43 per kl	2.38
	Mangaung - metered	R 2.89 per kl	4.82
	Mangaung - unmetered	R 5.84 per kl	9.73
	Bloemspruit	R 0.97 per kl	2.11
Public standpipes	Botshabelo	R 0.75 per kl	0.86
	Mangaung	R 0.00 per kl	0

Source: Palmer Development (1993b)

■ Tariffs differ widely within the region and within Botshabelo, with no apparent logic to the differences other than local political concerns and capital redemption costs.

■ Tariffs are generally too low to ensure cost recovery. Table 10 presents a theoretical exercise in determining the levels at which tariffs and levies should be set in order to meet one of two scenarios for cost recovery: firstly, that total expenditure is to be recovered, and secondly, that at least operating and maintenance costs are recovered.

These calculations are based on the estimate of total expenditure for 1992/93 of R 2.00 per kl (see Table 8), which is used as an indication of what an economic tariff in Botshabelo could be. A calculation of actual marginal costs was not attempted.

Table 10: Estimates of tariffs and levies needed to recover current expenditure

TYPE OF SUPPLY	CURRENT RETAIL PRICE (Rands)	COST RECOVERY PRICE (Rands)	% INCREASE NEEDED	NOTES
Full recovery of operating, maintenance and current capital costs (including loan redemption and projects)				
Metered site connections	0.90/kl	2.00/kl	222	See Table 8 for total expenditure estimate of R2.00/kl
Unmetered site connections	7.20/month	35.90/month	499	Based on an estimated consumption of 120l/c/d and 4.91 people/site
Public standpipes	2.40/month	14.90/month	621	Based on an estimated consumption of 50l/c/d and 4.61 people/site
Recovery only of total operating and maintenance costs (including bulk purchases)				
Metered site connections	0.90/kl	1.21/kl	34	See Table 8 for O&M estimate of R 1.21/kl
Unmetered site connections	7.20/month	21.70/month	301	Same as above
Public standpipes	2.40/month	9.04/month	377	Same as above

Assuming an average monthly income of R 750 per household in Botshabelo (based on Van der Merwe et al, 1992) payment of levies for unmetered on-site connections would be 4.4% of total monthly income, whereas levies for use of standpipes would be roughly 1% of monthly household income. Since, however, households using standpipes tend to be poorer than those with connections, the percentage of monthly income is likely to be higher.

3.2 Sanitation

a) Bulk

The activated sludge biological treatment plant in Botshabelo has a capacity of 20 Ml/day, but currently handles an average flow of 5Ml/day. The biological load is much higher than this figure suggests, since part of influent consists of night soil (approx. 1 Ml/day) and contents of pit latrines (approx. 0.05 Ml/day). Since July the plant has been managed by Bloemfontein Municipality on a contract basis.

b) Reticulation

Extent of reticulation

Four sanitation systems are operated (see Table 11).

Table 11: Access to sanitation systems

Level of access	Population	%	Blocks
Waterborne	17 000	8	H, industrial area
Pit latrines	144 000	65	C,E,F,J,K,L,M,N,S,T,U, W
Buckets	58 000	26	A,B,C,D,E,G,J
Conservancy tanks	1 000	1	Shops, schools, various
TOTAL	220 000	100	

- Waterborne sewerage: Block H, the industrial area and commercial centre are fully reticulated (1 378 connections). All sewage gravitates to the treatment works, except in a part of the industrial area.

- Conservancy tanks: 210 are installed at schools, shops, private homes (50) and the chicken farm (38). These are emptied on average twice a week by vacuum tankers which off-load at four dumping points on the main sewage pipeline.

- Bucket system: introduced as an emergency measure to cope with land invasions and with the inhibitive cost of blasting pits in the rock in some areas. Buckets from the 14 700 latrines are collected twice per week and emptied at oxidation ponds. A central washing facility serves all areas.

- Pit latrines: 31 000 latrines are provided for roughly 65% of residents. Pits are generally 1x1.5 m in plan. Latrines were installed by contractors, but are not VIP systems in terms of latest technology. They are constructed free of charge to the household.

c) System operation and costs

Bucket system

High incidence of typhoid and stomach fever in Botshabelo are largely blamed on problems in the operation of the bucket system[11]. During the decade of its operation it has been constantly hampered by a host of difficulties:

- A shortage of equipment, notably trucks.

[11] Sakkie Hettingh, Department of National Health.

- A shortage of personnel, particularly drivers.
- Problems with operation at the central bucket washing facility.
- Industrial and political action, notably over the last year.

It is also a very expensive system to operate: actual operating costs were calculated by Van Wyk & Louw (1992a) to be R 361.75 per plot per year. Households are currently only paying a levy of R5 per month (R60 per year, or 17% of actual costs). It follows that the system is currently subsidised by the state at an approximate cost of R 3.5 million per year.

Conservancy tanks

The 210 septic tanks function adequately, sharing the problem of a lack of vehicles to empty the tanks with the bucket system. The system is, however, very expensive to operate: an estimate of operating cost of R 6 283 per tank per year (Van Wyk & Louw, 1992a) implies an under-recovery of R82 per emptying of a tank (currently R8 is charged, or 9% of actual costs).

Pit latrines

According to reports from consultants (Van Wyk & Louw, 1992a; 1992b) and the town administration, the experience with pit latrines in Botshabelo over the last 15 years has been problematic. No detailed study has been undertaken on the operation of the system, but the low soil permeability and pit overflows seem to be the primary source of the problems:

- Grobler et al (1988) found soil permeability in Botshabelo to be low[12], as evidenced also by the number of pit latrines that overflow or have to be pumped out. The authors estimated that 90% of the contents of pit latrines remain either in the pit or its vicinity. The blocks most affected are L,J, and K.

- In low-lying areas stormwater enters pits and these overflow onto the flood plain areas and into the Klein Modder River. The areas most affected are U and T.

Further, according to Jagals (personal communication) many people are unwilling to use the pit latrines and therefore defecate in the veld. This has a direct impact on stormwater quality.

[12] The permeability factors in the area suggest that material originating in these pits will take between 7 and 70 years to travel a horizontal distance of 100 meters.

Such operating problems have two main consequences:

- Since a large proportion of the 31 000 pits essentially function as septic tanks, they have to be emptied on a regular basis. The local administration empties pits free of charge on average once every three years when residents report them as full or overflowing. The estimated total cost of this service is R33.64 per pit emptied per year (Van Wyk & Louw, 1992a). Currently the administration does not have sufficient personnel and equipment to cope with the number of requests for emptying.

- Pit latrines have been linked to poor water quality in the upper Modder River system. Jagals (1993) links high bacterial counts in the river system to the continuous overflowing of pit latrines during periods of significant rain (see Appendix A for a more detailed discussion of pollution hazards). Faecal coliform counts of stormwater have been measured at up to 1 X 10^6 per 100 ml, which is of the same order of magnitude as raw sewage. However, the pollution hazard applies mainly to surface water and bacterial pollution. The impervious nature of the local soils and the immobility of phosphorus in clay make it unlikely that pit latrines will pose a significant eutrophication or groundwater pollution hazard (Grobler et al, 1988), although some evidence of leaching was found by Jagals (1993).

Waterborne sanitation

Operational problems relate mainly to use patterns and operation of the sewerage system. Two types of use patterns cause concern: occasional industrial effluent entering the system and residential misuse of the system leading to blockages. Stormwater also enters the system on occasion, causing overflows at the treatment works. Concern about the effect of treatment works effluent on the Modder River system has been expressed in recent years:

- Jagals (1993) found high bacteria coliforms counts below the sewage plant and linked this to operating problems at the plant.

- Grobler et al (1988) found that effluent from the treatment works has the greatest impact on eutrophication in Mockes Dam, despite the smaller size of its load compared with non-point phosphate sources (mainly pit latrines). This point source is evenly distributed throughout time and reaches the dams and reservoirs in the upper Modder River system when they are most vulnerable.

The actual operating costs of the waterborne system have been calculated to be R 103.37 per plot per year if the whole city is reticulated (Van Wyk & Louw, 1992a). This is considered to be too low - an estimate based on the operating and maintenance costs for 1992/93

provides a current operating cost figure in the order of R 540 per plot per year[13]. A levy of R 1 per month is currently charged for this service, resulting in a total yearly subsidy of approximately R 1,9 million.

d) Issues in sanitation supply

The sanitation system in Botshabelo is not operating adequately: health problems, water pollution and high costs of subsidisation are currently associated with the various services operated in the city.

[13] An approximate estimate of the 1993/94 operating and maintenance budget: R 1 million (including personnel costs, maintenance of vehicles and equipment replacement) plus R 835 000 for the sewerage plant.

4. PROPOSALS FOR ADDRESSING ISSUES IN WATER AND SANITATION SUPPLY

4.1 Consultant reports

The issues surrounding water and sanitation supply in Botshabelo have been addressed by various consultants, academics and political commentators over the last decade. Three recent reports are briefly summarised below.

a) The ISEN reports

The University of the Orange Free State's Institute for Social and Economic Research (ISEN) has, between 1988 and 1992, produced 11 lengthy reports on various aspects of Botshabelo's economy and infrastructure for the DDA[14]. The proposals of the 1990 and 1992 De Vos reports in relation to the water and sanitation systems were:

Improving the water supply system

- Areas with insufficient standpipes should receive priority attention in the short-term.
- Reticulation should be extended over time, aiming for yard taps to replace standpipes in all areas.
- Information and record systems should be improved.
- Current high levels of subsidisation should be reconsidered.

Improving the sanitation system

- Address the persistent operating problems at the sewage treatment works.
- Introduce guidelines and standards for industrial effluent.
- Improve the maintenance procedures for vehicles and equipment.
- Phase out bucket system and replace with water-borne system in short and medium term.
- *As money becomes available and residents can afford it* (own emphasis), extend waterborne sewerage system to all areas.
- Reconsider low levels of cost recovery for services provided.
- Urgently educate users on the correct procedures with waterborne sanitation.

b) The Van Wyk & Louw 1992 'status quo' report

The engineering firm Van Wyk & Louw have been the main consultants for the DDA in planning and development infrastructure in Botshabelo. The 1992 'status quo' report was

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[14] Although this tremendous effort resulted in Botshabelo being one of the best studied townships in the country, very little of the analysis or proposals found application.

produced to provide the PAO with background information during the hand-over of the township administration from the DDA. The recommendations (and estimated costs) were:

Improving the water supply system

- Improve the water master plan (R60 000).
- Create adequate information systems on pipes and reservoirs (R 8 000).
- Investigate causes for pipe breakages (R20 000).
- Increase maintenance of pipelines (R240 000).
- Install yard taps and connections (R13 million).
- Complete reticulation in Block S.

Improving the sanitation system

- Phase out the bucket system. Replace with waterborne system, or if funds are not available, with pit latrines[15].
- Phase out conservancy tanks, but only if waterborne sewerage is installed.
- Improve maintenance of sewerage pipelines.
- Increase tariffs charged to the chicken farm.
- Fence and secure dumping points, oxidation ponds and bucket washing facility.
- Repair dumping points.

c) The Van Wyk & Louw 1993 Botshabelo water master plan

General recommendations

2013 population estimates should be revised from 753 000 to 270 000, which makes the development of areas XYZ not necessary. Consolidation and increased densities are to be achieved through infill housing in Blocks F,G,H,J,K,L and M.

Improving the bulk system

In order to comply with Bloem Water requirements (see page 13) it is proposed that the bulk system be upgraded at various stages. The Lesaka reservoirs need not be upgraded until 2003, whereas a capital programme would see all 2,0Ml reservoirs being upgraded to have a capacity of 5 or 6Ml by 2013. Improvements to the system design require a new pipeline between reservoirs 6 and 7 and a halt to direct withdrawal from the 450mm pipeline to reservoir 5.

[15] The 1988 report by Van Wyk & Louw on sanitation made provision for the full reticulation of blocks G,C,E,B and T in that order of importance. Reticulation of the whole settlement was estimated to require R 99 million.

Extending reticulation

The report proposes an upgrading process which would see the average daily consumption increase from the present 16,3 Ml/day to 24,9 Ml/day in 1998 and 51,5 Ml/day in 2013 (see Table 12).

Table 12: Proposed extension of reticulation

YEAR	BLOCKS	STATUS OF RETICULATION
1998	B,C,E,G,T	75% standpipes and 25% fully reticulated
2003	B,C,E,G,T	50% standpipes and 50% fully reticulated
	A,D,F,J,K,L,M,N,P,S,U,V,W	90% standpipes and 10% fully reticulated
2013	B,C,E,G,T	fully reticulated
	A,D,F,J,K,L,M,N,P,S,U,V,W	75% standpipes and 25% fully reticulated

4.2 Official responses

Official response to these recommendations has been slow or non-existant, given the complex institutional arrangements and the shortage of skilled technical staff and funds.

a) Bloem Water

Mnr Johan De Klerk, executive officer of the Board, sees the extension of waterborne sewerage to all residential areas as the only politically viable option in the short and medium term. The operation of the bucket system and the emptying of pit latrines are too sensitive to industrial disputes and sabotage. Bloem Water will not cross-subsidise the capital costs of reticulation works at Botshabelo, but may possibly assist the town in obtaining low-interest loans which would help keep levies and water tariffs affordable.

Priorities in improving the water and sanitation supply situation in Botshabelo are seen to be: education about payment of services; urgent loss management programmes; more accountable local government which communicates better with the community; and an accounting system which does not rely on 'soft-pursed' state finance. Pollution of surface water is not seen as a problem since takeover of the treatment works by Bloemfontein Municipality, and, should it prove to be a problem for Maselspoort, an envisaged new purification works could be built below Rustfontein Dam above the Klein Modder River. Health conditions in Botshabelo associated with buckets are an important concern at present.

b) Provincial Administration

Mr Johan Visser, Director of the Town Administration Branch responsible for managing former DDA towns, describes present management of the town as being in a 'crisis' mode which will only improve once national elections have taken place and new institutional arrangements are set in place. The state should not and cannot efficiently or effectively run a town, specially in the absence of a local negotiation forum with the community. Long contract procedures, slow equipment replacement and accounting procedures hamper progress in Botshabelo.

Despite the Van Wyk & Louw master planning, there is no official long-term capital programme at present. The PAO priorities relate to most immediate crises in the short-term: installing street/mast lightning; improving roads; providing more standpipes in areas with greatest shortage; and replacing the pit latrines and bucket system in the medium term by fully reticulating the whole township. Installed yard taps will not have meters, since these are sabotaged and are too expensive to read.

While a waterborne system is not economically justifiable at present, political demands make it an imperative, and according to Johan Visser, "*present political circumstances do not allow for decision-making on economic or engineering grounds*". The bucket system is not functioning adequately and a waterborne system will have to be introduced in the short to medium term to satisfy demands from the community and avoid future industrial action as experienced with the bucket system over the last year.

The state is expected to halt its subsidisation of Botshabelo in 2-3 years, which makes the introduction of economic tariffs an imperative if the R40 million shortfall on the operating account is to be reduced. But, according to Mr Visser, the politics of a tariff increase make such a step very difficult before the national elections.

c) Botshabelo Town Administration

The Town Secretary, Mr JC le Roux, is of the opinion that a future state will have to continue subsidising the operation and maintenance of the water and sanitation systems in the long run. But local government would have to be introduced since the state can not effectively manage a town.

Andrew Brink, Town Engineer, sees as the long-term goal an unmetered yard tap on every erf and waterborne sewerage in the whole township. Areas with greatest need should be

reticulated first. Existing meters are to be removed from erven and in future only fixed monthly levies will apply to the whole town. Waterborne sewerage should be installed first in areas where pollution risk is greatest.

d) Department of National Health and Population Development

The Department is responsible for health conditions in the town given the absence of a local authority. Mr Sakkie Hattingh of the Department argues that more bucket emptying points are needed and that decentralised washing facilities and depots should be introduced as a priority. Waterborne sewerage is seen as the only solution to health problems in the town.

4.3 Community demands and responses

The Botshabelo community is currently not well organised and no strong civic structures exist. Communication between the community and authorities has collapsed completely since the dismissal of 1000 town administration workers during the national "stay-a-way" in July 1992. Subsequent acts of sabotage and violence directed at new Administration workers have increased problems associated with the water and sanitation systems. Prior negotiations with the community have identified electricity provision and an improvement of the sanitation system as priority actions for the short-term.

4.4 Comment on proposals

From a technical and political point of view it seems logical, as the various parties argue, that waterborne sewerage should be introduced in the area as a whole as soon as funds are available. There are, however, a number of problems with this proposal which are generally ignored or not considered by the various parties involved in planning the infrastructure system.

a) Increase in water consumption

Full water reticulation in all areas is expected to double per capita water consumption (Van Wyk & Louw, 1993). The introduction of waterborne sewerage will furthermore increase the use of water per household substantially in areas where there are currently bucket and pit latrines. Overall water consumption for Botshabelo could increase to 43 Ml per day (16 at

present)[16], requiring an upgrading of the Lesaka scheme at a peak flow factor of 1.35 (present capacity is 52 Ml/day) (Van Wyk & Louw, 1993).

Although Bloem Water argues that sufficient water resources can be found to make such a 26% increase in one supply area possible, the high marginal costs of such added investment in bulk infrastructure is likely to place considerable strain on the Board and its consumers. The Free State is a dry region with limited water resources, and very careful thought such be given to such a substantial increase in water demand.

b) Worsening of cost recovery situation

Increased water consumption will require either substantially increased subsidies or sharp increases in levies and water tariffs. In section 2.1 the current low levels of cost recovery were outlined. When subsidies of capital costs are maintained but full costs for operation and maintenance recovered, the introduction of water-borne sewerage to all plots would require the following tariffs for water and sanitation (at current costs):

- Metered on-site connections: R 1.21/kl (22% increase of current tariff)
- Unmetered on-site connections: R 21.74 per month (302% increase for plot with yard connection at present, and a 906% increase for plots which currently use standpipes).

If the same subsidisation arrangement applies to the sanitation system, the introduction of water-borne sewerage would require monthly levies of the order of R 12.50 to R 41.50 per month (an increase between 1 250% and 4 150%). The treatment works is currently only operating at 25% of capacity, but would have to be expanded if the whole of Botshabelo is reticulated.

Reticulation and construction of outfall sewers for the blocks served by buckets (Blocks A,B,C,D,E,G, and J) were estimated at R 25 million (Van Wyk & Louw, 1992). Repayment of a loan to cover such expenditure would require R 3,8 million per year for 20 years (May 1992 estimate). Current levies and fees do not come close to covering operating and maintenance costs, implying that such capital expenditure would have to be subsidised by the state or some other regional authority[17].

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[16] The 1993 water master plan makes provision for average daily flow of 51.5 Ml/day to Botshabelo in 2013 through a construction programme of additional reservoirs.

[17] The sewerage plant has considerable spare capacity, and an increase in reticulation will increase only operating costs at the plant.

Such increases in monthly levies in Botshabelo are not possible given present income levels of most households. To subsidise such operating and maintenance costs in addition to capital costs would create a huge financial burden on the state or regional government which will not be sustainable in the medium to long run. Basing plans on assumptions of long-term subsidies to maintain local services is a gamble: **the only sustainable systems are those which are self-reliant**.

c) Increased water pollution

The 1987 report by Grobler et al argues that an increase in the use of waterborne sewerage could increase phosphate loads in the Modder River system. The sewerage works will cause the non-perennial Modder River to flow throughout the year, introducing phosphate-rich water to Mockes Dam during the dry months when the water body is most sensitive to eutrophication. If however, the treatment works operates to a high standard this danger may be avoided.

5. CONCLUSIONS

This study has highlighted a number of issues pertaining to the linkages between technical, environmental, management, political and financial aspects of water and sanitation supply in developing areas. The conclusions that are drawn from the study are applicable both for Botshabelo and other areas with similar characteristics.

The primary conclusions can be summarised as follows:

Viability of Botshabelo as an urban area

While Botshabelo has a history which is identified with apartheid planning, it needs to be recognised that it exists, provides homes for many people and contains a substantial investment in infrastructure and housing. The people of Botshabelo would lose twice if this infrastructure and related services delivery was allowed to deteriorate. Therefore, strategies must be devised to manage the provision of services properly and in a way which is sustainable in the long term.

Unsustainable financial situation

Currently, the operation, maintenance and capital costs of supplying of water and sanitation to Botshabelo are heavily subsidised by the state, partly because people are not paying services fees, but also because services fees are set substantially below actual cost. International experience indicates that the state can seldom sustain such levels of subsidy and is likely that, over time, these will be withdrawn or substantially reduced. Therefore it is important that Botshabelo move towards financial independence, possibly as part of the Bloemfontein metropolitan area. Otherwise a break-down of services will result when state funding of operating costs diminishes or ceases.

Appropriate sanitation systems

With the financial situation of Botshabelo already in a poor state, it is highly unlikely that subsidies will be increased to provide a waterborne sanitation system for all residents. Therefore, the existing sanitation systems need to be investigated with a view to improving their performance and managing them properly.

It is generally recognised that the bucket system is an inadequate and expensive form of sanitation (Palmer Development 1992) and this should be replaced as soon as possible. However, Ventilated Improved Pit (VIP) Latrines are an adequate and inexpensive sanitation option, and this option should not be ruled out. The reported difficulties with existing pits in rocky areas and with pits overflowing need to be investigated and the options for improving pit performance assessed. Only then can decisions be taken about VIPs as an appropriate sanitation option.

Environmental concerns

There is considerable uncertainty regarding the relative environmental impact of different sanitation systems. However, it can be argued that a waterborne sanitation system will be the least satisfactory from the point of view of environmental impact. Water use and effluent discharge into the Modder River will increase, as will the risk of pollution due to sewer failure and blockages. Current evidence suggests that well managed on-site sanitation system such as VIPs could have a lower environmental impact.

Local accounting and explicit subsidisation

The need for local government is recognised by all parties. Despite political constraints in the short term, tariffs will have to be increased in order to more accurately reflect the average or marginal cost of providing a service. Subsidisation should be made explicit and be directed at the most needy households and not be applied generally. In order for well informed financial decisions to be taken, a local accounting system should be introduced which presents income and expenditure figures for the various services provided.

Water conservation

If water is to be conserved and used wisely, some form of metering of household and municipal water consumption be should reintroduced. This will allow for the implementation of a water loss management programme and for an effective water charging and cost recovery programme to be introduced. Through this action, water will become properly valued and therefore better conserved by users.

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Paul Jagals

7. APPENDIX A: WATER POLLUTION ISSUES

Surface water pollution from Botshabelo into the Modder River system affects agricultural uses, aquaculture, Bloemfontein water supply from the Maselspoort works, and recreational uses, mainly at Mockes Dam (see). Although actual measured pollution in the river system has not been as serious as feared in the early 1980's (Toerien et al, 1983), evidence of high levels of faecal coliforms is being collected (Jagals, 1993).

Paul Jagals of the Technikon Environmental Unit is compiling a record of monthly e. coli and S faecalis counts from various points in Botshabelo and along the Modder River (Jagals, 1993). Readings over the last year at most points in Botshabelo have been consistantly worse than DWAF standards, particularly during rain storms after dry periods. Evidence exists that bacteria is accumulating within the river system and the lower reaches of Mockes Dam.

Monitoring of water quality in Mockes Dam by the Bloemfontein Municipality has shown baterial counts to be within DWAF limits over the last year, and except in the driest periods, little indication of eutrophication exists. The whole river system is thoroughly flushed in summer, reducing bacteria and phosphate concentrations[18].

Two aspects of the sanitation system are of particular concern:

Surface run-off from non-point sources

During rain storms, pits overflow into the Klein Modder via roads and green open spaces. Leach water flows on a constant basis for considerable periods after substantial rainfall. When the bucket and conservancy tank systems fail due to industrial or strike action or equipment failure, very high levels of faceal pollution enter the Klein Modder[19]. Acts of sabotage or misuse of the waterborne sewerage system also result in seepage which forms pools of digesting raw sewage. These pools not only cause a local health hazard, but also overflow into the river system. No research has been undertaken to study levels of groundwater pollution because Botshabelo does not rely on groundwater resources. It is expected, however, that long term groundwater pollution problems could result from pit latrines being used in inappropriate soil conditions[20].

Point source

The highest DWAF phosphate standards apply to the sewerage plant, but occasional spills and overflow due to hydraulic overload is thought to cause downstream pollution and eutrophication in Mockes Dam in winter months when the plant is the only source of water in the Modder River system (Jagals, 1993; Grobler et al, 1988; Toerien et al, 1983). High bacteria counts downstream of the plant remain of some concern.

Although the Water Quality Unit of the DWAF is concerned about the impact of sanitation systems on water quality in the Modder River system, the pollution threat has not been as serious as anticipated. Eutrophication of surface water in winter months and groundwater pollution are expected to become increasingly problematic in future[21].

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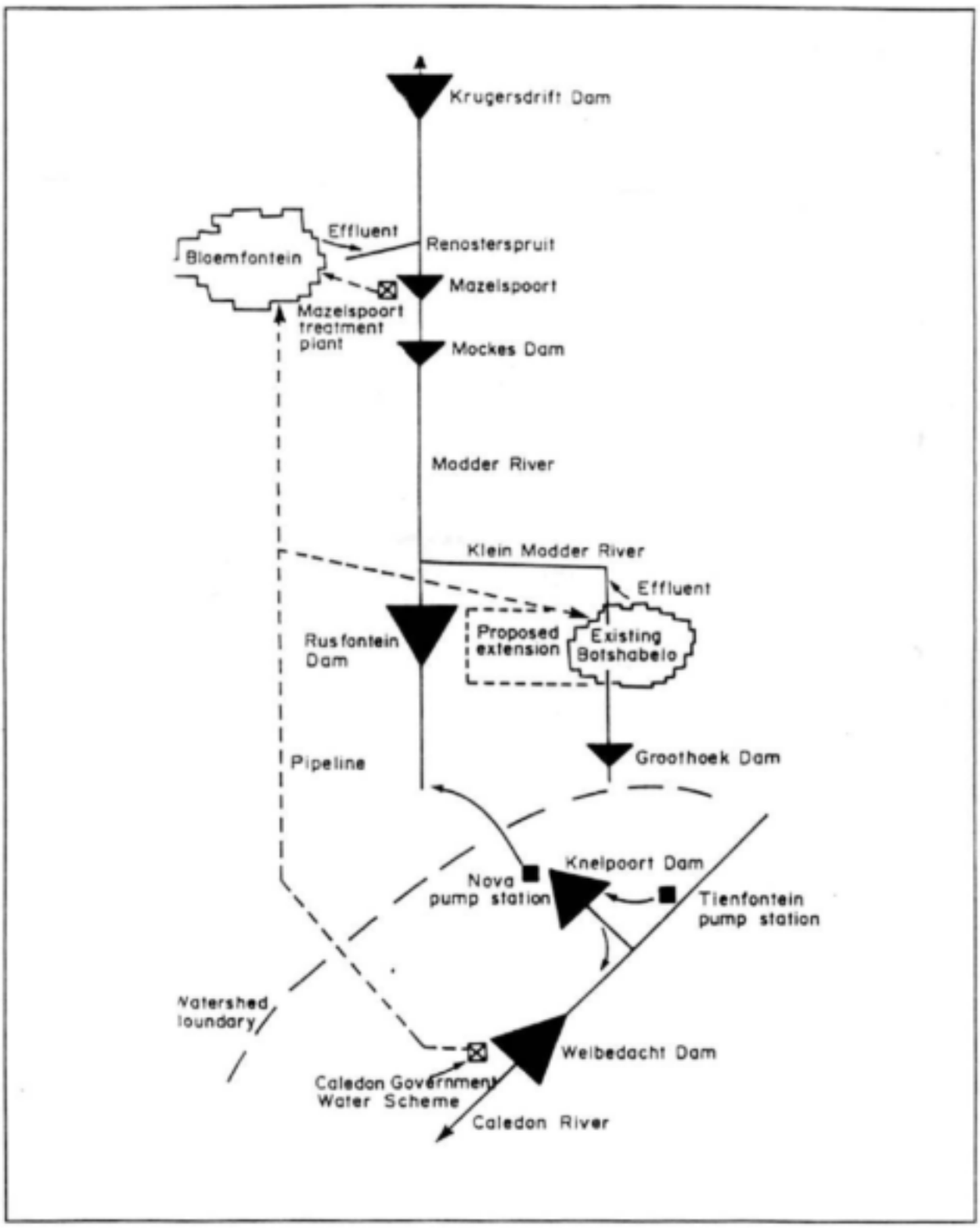
[18] Personal communication from Dr D. Theron, Chief Microbiologist, and Mnr P. Wagner, Chief Chemist.

[19] During the two-week strike by workers on the bucket system in January 1993, bacterial counts at all points along the Klein Modder River increased very sharply to levels far in excess of health regulation.

[20] Personal communication, Prof P. Botha, Institute for Groundwater Research.

[21] Personal communication from Dr J van der Merwe, Deputy Director, DWAF water Quality Control.

Figure VII: The position of Bosthabelo in relation to rivers and dams in the upper Modder River catchment.



8. APPENDIX B: TYPICAL BLOCK LAYOUTS

Figure VIII: Examples of typical block layouts