A WATER RESOURCES AND SANITATION SYSTEMS SOURCE BOOK WITH SPECIAL REFERENCE TO KWAZULU-NATAL:

PART 3

by

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Part 3 contains the following:

Chapter 10: A brief inventory of the surface water resources of Natal/KwaZulu — SURFACE WATER

Chapter 11: Groundwater in Natal/KwaZulu — GROUNDWATER

Chapter 12: Water supply planning for infrastructure provision — WATER SUPPLY

Each chapter has its own contents page/s. The pagination in **Part 3** is consecutive. A comprehensive set of contents pages for the entire thesis can be found in Part 1.

This thesis consists of the following:

- Part 1. Chapters 1 - 5
- Part 2. Chapters 6 - 9
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- Part 5. Chapters 16 - 17
- Part 6. Chapters 18 - 20

CHAPTER 10: A BRIEF INVENTORY OF THE SURFACE WATER RESOURCES OF NATAL/KWAZULU

An early description of the hydrological cycle...

> ***All the rivers run into the sea; yet the sea is not full: unto the place from whence the rivers come, thither they return again.***

Ecclesiastes, 1:7

CHAPTER 10: A BRIEF INVENTORY OF THE SURFACE WATER RESOURCES OF NATAL/KWAZULU

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10.1 Introduction

A wide range of information is presented in this chapter. The first part of the chapter concentrates on officially defined drainage catchments, as well as runoff and water demand data, plus sources of hydrological information and associated river data. The major dams in Natal/KwaZulu are listed in the next section, which is followed by a discussion of dam safety as well as the environmental impacts of dams and other water-related infrastructure. The second part of the chapter deals with some legal aspects of water supply and demand. A number of water control systems are accordingly examined. The final part of the chapter describes the various local authorities and agencies responsible for the provision of domestic water supplies in Natal/KwaZulu. Also included is a brief overview of civil defence (protection) - as undertaken by local authorities - with special reference to floods.

10.2 Precipitation and runoff in Natal/KwaZulu

Natal/KwaZulu is the most fortunate province of South Africa with regard to water resources (Table J1). A comparison of Natal/KwaZulu's water budget with the whole of South Africa (Table J2) reveals that proportionately in the province, there is nearly twice as much total runoff (direct surface runoff and groundwater recharge) per unit of rainfall, than in South Africa. Natal/KwaZulu with approximately 8% of the land area of South Africa, contributes 25% of South Africa's streamflow and 40% of the usable water resources (Schulze, 1979)*.

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* See Schulze, R.E., 1979. Hydrology and water resources of the Drakensberg, Natal Town and Regional Planning Commission Report, VOL 42, Pietermaritzburg, 179 p.

Table J1: Mean annual precipitation and approximate annual runoff density data for South Africa.

Province/country	Mean annual precipitation (mm)	Approximate annual runoff density (m^3 km^{-2})
Natal/KwaZulu	878	135 200
Transvaal	647	41 100
Orange Free State	590	25 900
Cape Province	360	30 636
Swaziland	865	125 900
Lesotho	848	150 900

<u>Source</u>: After Van Robbroeck, T.P.C., 1983. Address, In: Pegram, G.G.S. (ed), Natal's Water Resources: the Future, Proceedings of a Symposium, 12 October 1983, University of Natal, Durban, p. 4 - 35 (including discussion of the paper).

<u>Note</u>:

(i) Schulze, R.E., 1979. Hydrology and water resources of the Drakensberg, Natal Town and Regional Planning Commission Report, VOL 42, Pietermaritzburg, 179 p., refers to a mean annual rainfall of 927 mm for Natal/KwaZulu. The lowest rainfall areas in the province still receive approximately 150 mm y^{-1} more than the mean annual rainfall over South Africa (including Natal/KwaZulu), which is only 485 mm. Readers requiring climatological data for other countries in southern Africa should examine the following as a first approximation: Anonymous, 1984. Agroclimatological data for Africa, VOL 2: countries south of the equator, FAO Plant Production and Protection Series Report No. 22, Food and Agriculture Organization of the United Nations, Rome, 13 p. + app. (The publication - which is available in the Life Sciences Library, University of Natal, Pietermaritzburg - contains tabulated data for individual stations in the various countries).

(ii) About 25% of the runoff of Natal/KwaZulu originates at an altitude above 1 400 m (namely, in bioclimatic groups 4 and 5 - see the chapter on catchments, elsewhere in this publication).

Table J2: Water budgets for Natal/KwaZulu and South Africa.

Component of the water budget	Natal/KwaZulu		South Africa	
	water ($10^6 m^3$)	percentage	water ($10^6 m^3$)	percentage
Direct surface runoff	10 508	13,3	36 502	6,1
Groundwater recharge	2 512	3,2	16 893	2,8
Plant interception	14 409	18,3	70 100	11,6
Evapotranspiration	51 397	65,2	479 011	79,5
Rainfall	78 826	100	602 506	100

Source:
(i) After Schulze, R.E., 1979. Hydrology and water resources of the Drakensberg, Natal Town and Regional Planning Commission Report, VOL 42, Pietermaritzburg, 179 p.

(ii) After Whitmore, J.S., 1970. The hydrology of Natal, Paper No. 1, 2nd Technical Session, Symposium Water Natal 1970, 27 - 29 May 1970, Durban, 9 p. + app.

(iii) After Whitmore, J.S., 1971. South Africa's water budget, South African Journal of Science, VOL 67(3), p. 166 - 176.

10.3 Rivers of Natal/KwaZulu

The most important rivers in Natal/KwaZulu from south to north are the Mzimvubu (with reference to East Griqualand); the Mtamvuna; the Mzimkulu; the Mkomaas; the Illovo; the Mlazi; the Mgeni (main tributary the Msunduze); the Mdloti; the Mvoti; the Tugela (main tributaries the Mooi, the Bushmans, the Bloukrans, the Little Tugela, the Upper Tugela, the Klip, the Sundays, the Buffalo and the Blood); the Mhlatuze; the Mfolozi (tributaries the White Mfolozi and the Black Mfolozi); the Mkuze and finally, the Pongola-Usuthu River in the far north. It should be noted that four of South Africa's 10 largest rivers (in terms of mean annual runoff) namely, the Tugela, the Mzimvubu, the Mkomaas and the Mzimkulu (by comparison with other major rivers such as the Orange, the Vaal and the Limpopo), yield between 10 - 20 times more runoff per km^2 of catchment area (Perkins, 1986)*.

* See Perkins, J.C., 1986. The challenge of steep land in Natal and KwaZulu: water conservation and water development, In: Symposium on the Challenge of Steep Land in Natal and KwaZulu, Natal Branch of the South African Society for Agricultural Extension, 16 September 1986, Cedara, 4 p.

The distribution of the catchment areas of the 71 main rivers in Natal/KwaZulu, is outlined in Table J3. Approximately 50% of the catchments are less than 40 km^2 in extent. Six of the rivers in Natal/KwaZulu are longer than 200 km, while 22 rivers are less than 10 km in length, with 39 rivers less than 20 km in length. Nine rivers rise at an elevation greater than 1 000 m, 22 rivers rise at an elevation of more than 500 m, with 66 rivers rising at an altitude of more than 100 m. The overall gradients of the rivers in Natal/KwaZulu are generally steep (Table J4). Such gradients however, are variable along the length of the rivers and especially along the lower reaches. A few examples to illustrate this trend are provided in Table J5.

Table J3: Distribution of the catchment areas of the 71 main rivers in Natal/KwaZulu.

Area (km^2)	Number of catchments	Percentage
1 - 10	8	11
11 - 20	16	23
21 - 50	15	21
51 - 250	13	18
251 - 500	4	6
501 - 1 000	7	10
1 001 - 2 000	1	1
2 001 - 4 000	2	3
4 001 - 8 000	3	4
8 001 - 16 000	1	1
16 001 - 32 000	1	1

<u>Source</u>: After Anonymous, 1990. Hydro factors affecting siltation in the lower reaches of Natal/KwaZulu rivers, CSIR Report No. EMA-D 9006, Division of Earth, Marine and Atmospheric Science and Technology, CSIR, Stellenbosch, 22 p. + app.

Table J4: Overall gradient distribution of the 71 main rivers in Natal/KwaZulu.

Overall gradient (1:)	Number of rivers	Percentage
0 - 25	3	4
26 - 50	24	34
51 - 100	27	38
101 - 200	13	18
201 - 400	4	6

Source: After Anonymous, 1990. Hydro factors affecting siltation in the lower reaches of Natal/KwaZulu rivers, CSIR Report No. EMA-D 9006, Division of Earth, Marine and Atmospheric Science and Technology, CSIR, Stellenbosch, 22 p. + app.

Table J5: Examples of rivers in Natal/KwaZulu with variable gradients (north to south).

River	Overall gradient	Gradient over lowest given distance
Mfolozi	1 : 240	1 : 1 724 over lowest 100 km
Mhlatuze	1 : 165	1 : 1 075 over lowest 51 km
Tugela	1 : 130	1 : 1 905 over lowest 12 km
Mvoti	1 : 133	1 : 424 over lowest 32 km 1 : 773 over lowest 4,3 km
Tongati	1 : 67	1 : 645 over lowest 10 km
Mgeni	1 : 127	1 : 385 over lowest 16 km
Manzimtoti	1 : 42	1 : 357 over lowest 3 km
Mkomazi	1 : 112	1 : 1 111 over lowest 16 km
Mpambanyoni	1 : 104	1 : 213 over lowest 19 km 1 : 460 over lowest 2,3 km
Mtwalume	1 : 86	1 : 357 over lowest 4 km
Mzumbe	1 : 90	1 : 310 over lowest 3 km
Mzimkulu	1 : 135	1 : 1 000 over lowest 16 km
Mbizana	1 : 54	1 : 521 over lowest 2,4 km
Mtamvuna	1 : 84	1 : 769 over lowest 10 km

Source: After Anonymous, 1990. Hydro factors affecting siltation in the lower reaches of Natal/KwaZulu rivers, CSIR Report No. EMA-D 9006, Division of Earth, Marine and Atmospheric Science and Technology, CSIR, Stellenbosch, 22 p. + app.

Forty-one river profiles including surface geology, gradient, height above sea level and distance from source, plus existing and possible dam sites as well as sections of rivers flowing through KwaZulu territory, or rivers forming the boundary with KwaZulu, are presented in Thorrington-Smith, Rosenberg and McCrystal, 1978. Towards a plan for KwaZulu: a preliminary development plan, VOL 1, The written report, 341 p., and VOL 2, Atlas of maps and illustrations, various pages, KwaZulu Government, Ulundi. Similar data (including catchment area maps) can be found in Ninham Shand and Partners, 1971. Water resources of the Natal South Coast, Natal Town and Regional Planning Commission Report, VOL 18A, 31 p. + app., and VOL 18B, Appendices, various pages, Pietermaritzburg; as well as in Chew, J.A. and Bowen, 1971. The water resources of the coastal areas of northern Natal and Zululand, Natal Town and Regional Planning Commission Report, VOL 17, Pietermaritzburg, 18 p. + app.

10.4 Drainage catchments and related data in Natal/KwaZulu

South Africa is divided into a number of primary, secondary, tertiary and quaternary catchments. The four main (primary) drainage regions in Natal/KwaZulu as determined by the Department of Water Affairs and Forestry, are from north to south - the W, V, U and T regions. Parts of the W drainage region are outside Natal/KwaZulu, while most of the T drainage region is in the Transkei. The secondary drainage regions, also as defined by the Department of Water Affairs and Forestry for Natal/KwaZulu are: W10, W20, W30, W40 and W70 (W primary drainage region - the Mhlatuze, Mfolozi, Mkuze and Pongola-Usuthu catchments)*; secondary drainage regions V10, V20, V30, V40, V50, V60 and V70 (V primary drainage region which is wholly situated within Natal/KwaZulu - the Tugela catchment); secondary drainage regions U10, U20, U30, U40, U50, U60, U70 and U80 (U primary drainage region which is likewise wholly situated in Natal/KwaZulu - the Mkomaas and Mgeni catchments), and secondary drainage regions T30, T40 and T50 (T primary drainage region - the Mzimkulu, Mtamvuna and Mzimvubu catchments). Area and runoff data for the secondary drainage regions are presented in Table J6. Readers should bear in mind that the Department of Water Affairs and Forestry applies a further coding

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* Note that W50(0) and W60(0) are not in Natal/KwaZulu. Secondary catchments are most often referred to without the third digit, for example, W60 is the same catchment as W600. The far northern Zululand coastal plain is in secondary catchment W70, which is an area with an enclosed drainage pattern. Localized runoff only is found in conjunction with wetlands (pans).

system to secondary drainage regions, for example U2̲0 = 192̲0. The latter system, while still in use, is now outdated.

The Hydrological Research Unit (since defunct) of the University of the Witwatersrand similarly, divided South Africa into numerous tertiary catchments and many quaternary sub-catchments*. Such catchments are denoted by the abbreviation (HRU). Fifty-three tertiary catchments and over 300 quaternary sub-catchments are found in Natal/KwaZulu (Tables J7 and J8).

A cross reference for Department of Water Affairs and Forestry secondary drainage regions and HRU quaternary sub-catchments is outlined in Table J9. A difference in the subdivision of boundaries and nomenclature between the HRU and the Department of Water Affairs and Forestry in terms of catchments, means that most of HRU tertiary catchments V07A/B for example, are situated within secondary drainage region V20 with a small part in region V60. The initial letter of the respective codes will however, always be the same with regard to secondary drainage regions and HRU tertiary or quaternary catchments, indicating that the HRU catchment forms part of the given primary drainage region. A current project just finalized, will rationalize differences between Department of Water Affairs and Forestry and HRU catchments, so that only one main system of catchments (including catchment subdivisions) will be applicable in South Africa. Readers are advised that catchment information (especially for quaternary sub-catchments), will change. Various data relating to quaternary sub-catchments in Natal/KwaZulu (the averaging or summation of which, provides the data for tertiary catchments), are presented in Table J10.

The Hydrological Research Unit defined 10 hydrological zones (zones of similar hydrological response) for Natal/KwaZulu, namely, zones Z1 - Z3; Z5 - Z8; Z10; Z12, and Z13. Schulze (1984)**, re-examined the hydrological zones of Natal/KwaZulu, and found

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* See Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, as well as Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

** See Schulze, R.E., 1984. An assessment of the surface water resources of Natal, Natal Town and Regional Planning Commission Report, VOL 63, Pietermaritzburg, 44 p. and map.

(when runoff : rainfall relationships were plotted), that hydrological zones Z1 - Z3; Z6 - Z8 and Z13 had to be subdivided, sometimes into a number of sub-zones, for example, 8a, 8b and 8c. Accordingly, zones of similar hydrological response in Natal/KwaZulu were re-organized into 21 ACRU (Agricultural Catchments Research Unit) runoff regions. It should be noted that region 01 designates the area in north eastern Natal/KwaZulu stretching from St Lucia to Kosi Bay and inland, where no runoff records for simulation are available, effectively resulting in 20 runoff regions rather than 21. For each of the ACRU regions, mean annual runoff (MAR) versus mean annual precipitation (MAP) was plotted for all quaternary sub-catchments in a specific runoff region. The resultant runoff equations in terms of rainfall and other relevant data for the 20 ACRU runoff regions are presented in Table J11. Where apparent errors were found in the HRU quaternary catchments data (38% of cases), subsequently corrected by Midgley, Pitman and Middleton (1983)*, runoff : rainfall plots had to be constructed by Schulze, from the simulated runoff and rainfall data provided by the Hydrological Research Unit. Several runoff maps, briefly discussed later in the chapter, can be found in Schulze (1984).

Table J6: Mean annual runoff and other data for secondary drainage regions in Natal/KwaZulu.

Secondary drainage region	Area of region (km^2)	Mean annual precipitation (mm)	Mean annual runoff ($10^6 m^3$)	Percentage of total annual South African runoff
W W10	5 639	1 030	969	1,81
W20	10 061	849	885	1,65
W30	9 574	792	395	0,74
W40	11 785	828	1 253	2,34
W70	2 638	648	100	0,19
Summation	39 697	-	3 602	6,73
V V10	7 600	984	1 795	3,35
V20	2 880	892	522	0,97
V30	9 792	848	1 290	2,41

* See Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1983. An addendum to "Surface Water Resources of South Africa" (1981), Water Research Commission, Pretoria, various pages.

Table J6: **Mean annual runoff and other data for secondary drainage regions in Natal/KwaZulu (continued).**

Secondary drainage region	Area of region (km^2)	Mean annual precipitation (mm)	Mean annual runoff ($10^6 m^3$)	Percentage of total annual South African runoff
V40	1 750	890	191	0,36
V50	1 349	1 027	149	0,28
V60	3 675	773	309	0,58
V70	1 920	925	333	0,62
Summation	28 966	894	4 589	8,57
U U10	4 371	982	1 036	1,94
U20	4 425	945	683	1,28
U30	1 301	1 085	271	0,51
U40	2 747	1 035	483	0,90
U50	294	1 100	55	0,10
U60	1 517	926	190	0,35
U70	1 104	952	140	0,26
U80	2 508	937	316	0,59
Summation	18 267	979	3 174	5,93
T T30	19 781	902	2 968	5,55
T40	2 201	985	460	0,86
T50	6 675	748	1 472	2,75
T60	3 741	1 092	1 040	1,94
Summation	32 398	-	5 940	11,10
Total	119 328	-	-	32,33

Source: After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: (i) Data may include portions of adjacent territory outside Natal/KwaZulu. Secondary drainage regions W50 and W60 are not in Natal/KwaZulu, while much of secondary drainage regions T30 and T60 is in the Transkei.

(ii) A small part of KwaZulu (situated in the Transvaal) lies within secondary drainage region W40.

(iii) The mean annual precipitation for the W primary drainage region (W10 - W70 inclusive) is 857 mm, and 941 mm for the T primary drainage region (T10 - T90 inclusive). The mean annual runoff for the W primary drainage region is 5 894 x $10^6 m^3$, and 8 501 x $10^6 m^3$ for the T primary drainage region. The percentage of total annual South African runoff for the W primary drainage region is 11,01%, and 15,88% for the T primary drainage region. The total area of the W and T primary drainage regions is 60 272 km^2 and 46 525 km^2 respectively.

Table J7: Approximate location of Hydrological Research Unit (HRU) tertiary catchments in Natal/KwaZulu.

HRU tertiary catchment	Magisterial district
W	
W11	Eshowe, Mtunzini
W12	Mtunzini, Eshowe
W13	Nkandla, Mtonjaneni, Babanango, Eshowe
W14	Mtonjaneni, Eshowe, Lower Umfolozi
W15	Lower Umfolozi
W21	Vryheid
W22	Nqutu, Babanango, Vryheid
W23	Babanango
W24	Vryheid, Mahlabatini, Nongoma
W25	Mahlabatini, Nongoma
W26	Lower Umfolozi
W31	Vryheid, Ngotshe
W32	Nongoma, Ngotshe, Ubombo
W33	Nongoma, Ubombo, Hlabisa
W35	Hlabisa
W36	Hlabisa
W41	Utrecht, Wakkerstroom, Piet Retief, Paulpietersburg
W42	Paulpietersburg, Utrecht, Vryheid
W43	Paulpietersburg, Vryheid, Ngotshe, Piet Retief, Hlatikulu
W44	Ngotshe, Piet Retief, Hlatikulu

Table J7: Approximate location of Hydrological Research Unit (HRU) tertiary catchments in Natal/KwaZulu (continued).

HRU tertiary catchment	Magisterial district
W45	Ngwavuma, Ubombo
W46B	Ngwavuma (Swaziland irrigation district)
V	
V01A	Bergville
V01B	Bergville
V02	Klip River, Weenen, Estcourt
V03A	Estcourt
V03B	Estcourt, Weenen, Msinga
V04	Dundee, Klip River, Msinga
V05	Dannhauser, Newcastle, Utrecht, Volksrust, Wakkerstroom
V06	Dundee, Nqutu, Utrecht
V07A	Estcourt, Lions River
V07B	Kranskop, Umvoti, Weenen, Mooi River, Estcourt
V08	Eshowe, Kranskop, Nkandla
U	
U11	Umzinto, Ixopo
U12	Mpendle, Polela, Underberg
U13A	Polela, Ixopo, Richmond
U13B	Ixopo, Richmond, Umlazi
U21	Richmond, Camperdown, Umlazi
U22	Richmond, Pietermaritzburg, Camperdown, Umlazi, Pinetown, Durban
U23A	Mpendle, Lions River, Pietermaritzburg, New Hanover
U23B	Pietermaritzburg, Camperdown, Pinetown, Durban, New Hanover, Ndwedwe, Inanda
U30	Ndwedwe, Inanda, Lower Tugela
U40	Umvoti, Kranskop, Mapumulu, Lower Tugela
T	
T31	Matatiele, Mount Currie, Mount Frere*, Mount Ayliff*
T32	Matatiele, Mount Currie, Mount Frere*, Mount Fletcher* (small portion of catchment only, in Natal/KwaZulu)
T35	Mount Currie, Mount Ayliff*, Flagstaff*, Tabankulu*, Lusikisiki*, Bizana*

Table J7: Approximate location of Hydrological Research Unit (HRU) tertiary catchments in Natal/KwaZulu (continued).

HRU tertiary catchment	Magisterial district
T41	Alfred, Port Shepstone, Bizana*, Mount Ayliff*
T42	Port Shepstone
T51	Underberg, Polela
T52	Underberg, Polela, Mount Currie, Umzimkulu*
T53	Polela, Ixopo, Umzimkulu*
T54	Umzimkulu* (small portion of catchment only, in Natal/ KwaZulu)
T55	Alfred, Port Shepstone, Ixopo

<u>Source</u>: After Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, as well as Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

<u>Note</u>:

(i) HRU tertiary catchment W34 does not exist, while tertiary catchment W46A is in Swaziland.

(ii) Parts of quaternary sub-catchments or individual quaternary sub-catchments themselves, may lie outside Natal/KwaZulu. Readers should consult maps showing the location of tertiary and quaternary catchments, found in the above two references.

(iii) Districts marked with an asterisk are in the Transkei. The district of Matatiele is no longer a legal entity, and is part of the Mount Currie Magisterial District.

Table J8: Hydrological Research Unit (HRU) tertiary and quaternary catchments in Natal/KwaZulu.

Tertiary catchment code number	Quaternary sub-catchment code number	Hydrological zone
W W11	W110 - W116	Z7
W12	W121 - W125	Z7
W13	W131 - W136	Z7
W14	W141 - W146	Z7
W15	W151 - W157	Z7
W21	W211 - W217	Z12
W22	W221 - W226	Z12
W23	W231 - W239	Z12
W24	W241 - W248	Z8
W25	W251 - W256	Z8
W26	W261 - W267	Z13
W31	W311 - W317	Z8
W32	W321 - W326	Z13
W33	W331 - W339	Z13
W35	W351 - W354	Z13
W36	W361 - W366	Z13
W41	W411 - W419	Z5
W42	W421 - W424	Z5
W43	W431 - W439	Z5
W44	W441 - W448	Z13
W45	W451 - W456	Z13
W46A W46B	W461 - W463 W464 - W466	W461 - W463 (Z5) W464 - W466 (Z13)
V V01A V01B	V011 - V017 V014 - V019	V011 - V013; V016; V017 (Z3) V014; V015; V018; V019 (Z10)
V02	V021 - V029	Z10

Table J8: Hydrological Research Unit (HRU) tertiary and quaternary catchments in Natal/KwaZulu (continued).

Tertiary catchment code number	Quaternary sub-catchment code number	Hydrological zone
V03A V03B	V031 - V033 V034 - V039	V031 - V033 (Z3) V034 - V039 (Z10)
V04	V041 - V049	Z10
V05	V051 - V059	Z10
V06	V061 - V069	Z10
V07A V07B	V071 - V073 V074 - V079	V071 - V073 (Z3) V074 - V079 (Z10)
V08	V081 - V089	Z7
U U11	U111 - U119	Z6
U12	U121 - U129	Z3
U13A U13B	U131 - U136 U137 - U139	Z6 Z6
U21	U211 - U219	Z6
U22	U221 - U228	Z6
U23A U23B	U231 - U234 U235 - U239	U231 - U234 (Z2) U235 - U239 (Z6)
U30	U301 - U308	Z6
U40	U401 - U409	Z6
T T31	T311 - T319	Z3
T32	T321 - T329	Z5
T35	T351 - T359	Z3
T41	T411 - T419	Z1
T42	T421 - T428	Z1
T51	T511 - T519	Z2
T52	T521 - T529	Z2
T53	T531 - T537	Z1
T54	T541 - T549	Z1
T55	T551 - T558	Z1

Source: After Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, as well as Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

Note:

(i) HRU tertiary catchment W34 does not exist, while tertiary catchment W46A is in Swaziland.

(ii) Parts of quaternary sub-catchments or individual quaternary sub-catchments themselves, may lie outside Natal/KwaZulu. Readers should consult maps showing the location of tertiary and quaternary catchments, found in the above two references.

Table J9: Cross reference of Department of Water Affairs and Forestry secondary drainage regions and Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu.

Department of Water Affairs and Forestry secondary drainage region	HRU quaternary sub-catchment code number
W W11 = 2111	W110 - W116
W12 = 2112	W131 - W136 W141 - W146 W151 - W157
W13 = 2113	W121 - W125
W21 = 2121	W211 - W217 W221 - W226 W231 - W239 W262
W22 = 2122	W241 - W248 W251 - W256 W261
W23 = 2123	W263 - W267
W30 = 2130	W311 - W317 W321 - W326 W331 - W339 W351 - W354 W361 - W366

Table J9: Cross reference of Department of Water Affairs and Forestry secondary drainage regions and Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Department of Water Affairs and Forestry secondary drainage region	HRU quaternary sub-catchment code number
W41 = 2141	W421 - W424 W431 - W432 W435
W42 = 2142	W411 - W419 W436 - W439 W433 W434
W43 = 2143	W461 - W466
W44 = 2144	W441 - W448
W45 = 2145	W451 - W456
V V10 = 2010	V011 - V019 V021 - V029 V036 - V037
V20 = 2020	V071 - V078
V30 = 2030	V051 - V059 V061 - V068 V069
V40 = 2040	V081 - V086
V50 = 2050	V087 - V089
V60 = 2060	V039 V041 - V049 V079
V70 = 2070	V031 - V035 V038
U U10 = 1910	U121 - U129 U131 - U139
U20 = 1920	U231 - U239
U30 = 1930	U301 - U308
U40 = 1940	U401 - U408
U50 = 1950	U409
U60 = 1960	U221 - U228
U70 = 1970	U211 - U219
U80 = 1980	U111 - U119

Table J9: Cross reference of Department of Water Affairs and Forestry secondary drainage regions and Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Department of Water Affairs and Forestry secondary drainage region	HRU quaternary sub-catchment code number
T T30 = 1830	T311 - T319 T321 - T329 T351 - T359
T40 = 1840	T411 - T419 T421 - T428
T50 = 1850	T511 - T519 T521 - T529 T531 - T537 T541 - T549 T551 - T558
T60 = 1860	T431 - T438 T441 - T449 T451 - T459 T461 - T469

__Source__: After Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1983. An addendum to "Surface Water Resources of South Africa" (1981), Water Research Commission, Pretoria, various pages.

__Note__:

(i) HRU tertiary catchment W34 does not exist.

(ii) Department of Water Affairs and Forestry catchment: 2143(W43) has partly no equivalent in HRU.

(iii) Department of Water Affairs and Forestry catchment: 2145(W451) has partly no equivalent in HRU.

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu.**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
W			
W110	1 147	135	30
W111	1 155	150	32
W112	1 141	90	18
W113	1 121	130	26
W114	1 113	120	22
W115	1 126	255	52
W116	1 100	115	20
	Mean 1 129	Total 995	Total 200
W121	1 173	135	28
W122	1 124	65	12
W123	1 151	105	21
W124	1 306	95	29
W125	1 286	110	32
	Mean 1 210	Total 510	Total 122
W131	1 018	210	34
W132	983	295	41
W133	935	125	15
W134	936	260	31
W135	1 015	165	26
W136	890	240	24
	Mean 961	Total 1 295	Total 171
W141	867	155	17
W142	858	100	10
W143	844	160	16
W144	826	225	19
W145	826	280	27
W146	851	240	23
	Mean 841	Total 1 160	Total 112

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff (10^6m^3)
W151	809	280	18
W152	964	245	29
W153	1 006	195	25
W154	1 151	210	47
W155	1 056	180	29
W156	1 313	300	105
W157	1 256	370	109
	Mean 1 095	Total 1 780	Total 362
W211	922	275	30
W212	885	120	12
W213	980	235	33
W214	839	270	21
W215	758	130	7
W216	961	255	34
W217	768	190	12
	Mean 885	Total 1 475	Total 149
W221	752	220	12
W222	752	400	22
W223	738	320	17
W224	745	300	16
W225	840	355	31
W226	809	340	25
	Mean 774	Total 1 935	Total 123
W231	904	165	18
W232	898	230	26
W233	796	170	13
W234	821	185	15
W235	806	110	8
W236	814	245	18

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff (10^6m^3)
W237	779	275	18
W238	801	185	14
W239	758	140	8
	Mean 820	Total 1 705	Total 138
W241	849	340	30
W242	922	415	53
W243	825	210	18
W244	1 094	205	45
W245	960	285	45
W246	849	260	23
W247	787	270	18
W248	812	285	20
	Mean 884	Total 2 270	Total 252
W251	826	255	26
W252	836	265	30
W253	763	125	10
W254	799	135	13
W255	774	305	24
W256	782	190	17
	Mean 800	Total 1 275	Total 120
W261	750	90	3
W262	760	170	5
W263	789	185	6
W264	887	225	11
W265	835	240	9
W266	1 059	240	23
W267	1 236	265	46
	Mean 936	Total 1 415	Total 103
W311	903	210	20

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
W312	908	165	15
W313	908	205	21
W314	1 106	155	32
W315	946	170	20
W316	958	195	24
W317	792	330	20
	Mean 912	Total 1 430	Total 152
W321	840	200	10
W322	678	170	4
W323	717	135	4
W324	652	205	4
W325	665	300	6
W326	640	240	4
	Mean 693	Total 1 250	Total 32
W331	789	290	11
W332	691	320	8
W333	762	245	9
W334	675	225	5
W335	714	180	5
W336	576	435	6
W337	689	215	5
W338	590	90	1
W339	680	135	3
	Mean 684	Total 2 135	Total 53
W351	803	235	16
W352	740	140	7
W353	658	170	6
W354	670	165	6
	Mean 724	Total 710	Total 35

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
W361	926	275	17
W362	901	445	26
W363	820	380	16
W364	925	330	21
W365	863	310	16
W366	1 070	250	27
	Mean 908	Total 1 990	Total 123
W411	1 094	270	81
W412	1 074	120	31
W413	1 062	225	58
W414	1 012	165	36
W415	960	110	18
W416	984	275	54
W417	959	200	36
W418	918	540	85
W419	862	380	49
	Mean 972	Total 2 285	Total 448
W421	1 055	245	64
W422	963	260	49
W423	964	225	43
W424	948	265	49
	Mean 981	Total 995	Total 205
W431	904	250	44
W432	928	385	76
W433	883	275	44
W434	866	230	32
W435	851	135	20
W436	870	280	44
W437	812	365	44

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
W438	826	265	32
W439	837	470	64
	Mean 863	Total 2 655	Total 400
W441	790	255	9
W442	792	285	11
W443	714	245	6
W444	747	240	7
W445	622	245	4
W446	710	160	4
W447	640	325	6
W448	647	185	3
	Mean 708	Total 1 940	Total 50
W451	748	255	12
W452	639	275	8
W453	711	200	9
W454	723	235	10
W455	552	195	3
W456	569	420	8
	Mean 648	Total 1 580	Total 50
W461	880	310	25
W462	949	150	16
W463	881	350	29
W464	757	380	15
W465	633	375	8
W466	775	175	7
	Mean 795	Total 1 740	Total 100
V			
V011	1 220	720	287
V012	1 490	433	271

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
V013	1 299	572	269
V014	833	251	33
V015	979	433	102
V016	1 125	484	161
V017	1 063	267	70
V018	847	521	73
V019	755	425	35
	Mean 1 093	Total 4 105	Total 1 301
V021	1 091	342	102
V022	895	254	37
V023	817	174	18
V024	1 015	277	66
V025	985	290	62
V026	838	184	21
V027	804	575	56
V028	779	192	17
V029	743	298	22
	Mean 888	Total 2 585	Total 401
V031	1 291	249	114
V032	1 216	150	60
V033	1 017	124	28
V034	887	461	47
V035	764	446	39
V036	842	311	59
V037	735	614	46
V038	787	417	41
V039	731	427	32
	Mean 852	Total 3 199	Total 466
V041	1 026	233	56

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
V042	852	194	23
V043	879	223	31
V044	837	326	36
V045	741	277	20
V046	709	394	24
V047	735	409	28
V048	729	482	32
V049	726	422	28
	Mean 782	Total 2 960	Total 278
V051	961	689	132
V052	947	487	86
V053	905	370	60
V054	943	818	148
V055	1 022	531	125
V056	876	692	93
V057	853	717	88
V058	858	526	67
V059	766	1 233	102
	Mean 888	Total 6 063	Total 901
V061	836	557	66
V062	759	487	39
V063	849	306	37
V064	792	399	38
V065	750	275	21
V066	757	464	37
V067	761	523	43
V068	806	655	72
V069	783	355	35
	Mean 788	Total 4 020	Total 388

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff (10^6m^3)
V071	1 019	150	41
V072	1 026	205	58
V073	1 038	440	133
V074	948	122	22
V075	889	720	108
V076	828	702	90
V077	770	199	18
V078	766	350	31
V079	745	251	20
	Mean 880	Total 3 139	Total 521
V081	906	246	22
V082	1 035	264	39
V083	901	280	24
V084	845	357	29
V085	739	181	8
V086	884	378	31
V087	958	559	62
V088	1 070	570	91
V089	1 102	194	33
	Mean 949	Total 3 030	Total 339
U			
U111	1 030	130	38
U112	903	536	71
U113	1 038	127	22
U114	943	317	36
U115	917	248	24
U116	920	239	25
U117	985	234	35
U118	895	562	52

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff (10^6m^3)
U119	1 004 Mean 937	107 Total 2 500	14 Total 317
U121	1 365	171	106
U122	1 151	225	90
U123	1 214	381	176
U124	1 113	300	109
U125	1 043	300	88
U126	964	325	58
U127	979	135	31
U128	960	282	60
U129	953 Mean 1 079	293 Total 2 412	60 Total 778
U131	913	137	24
U132	914	254	45
U133	898	264	45
U134	854	155	22
U135	888	132	23
U136	836	362	50
U137	778	166	11
U138	790	210	15
U139	866 Mean 859	218 Total 1 898	23 Total 258
U211	1 064	114	22
U212	896	145	15
U213	861	137	13
U214	883	96	10
U215	914	106	12
U216	967	98	14
U217	966	197	26

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
U218	1 040	88	16
U219	1 079	57	12
	Mean 952	Total 1 038	Total 140
U221	983	143	19
U222	813	286	18
U223	762	205	9
U224	800	141	9
U225	989	197	36
U226	1 037	242	57
U227	923	129	13
U228	985	205	29
	Mean 926	Total 1 548	Total 190
U231	977	344	60
U232	973	410	84
U233	1 095	394	112
U234	913	619	94
U235	927	438	49
U236	925	409	47
U237	877	1 043	102
U238	1 050	256	46
U239	949	519	89
	Mean 945	Total 4 432	Total 683
U301	1 028	118	26
U302	1 134	179	33
U303	1 099	203	55
U304	1 073	145	29
U305	1 102	138	22
U306	1 110	105	21
U307	1 064	193	32

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
U308	1 085	320	52
	Mean 1 085	Total 1 401	Total 270
U401	882	329	33
U402	953	526	56
U403	959	254	33
U404	1 138	212	57
U405	1 137	274	66
U406	1 081	587	90
U407	1 117	215	48
U408	1 075	432	85
U409	1 100	326	69
	Mean 1 043	Total 3 155	Total 537
T			
T311	984	485	69
T312	882	425	41
T313	868	480	42
T314	760	375	21
T315	821	625	46
T316	967	380	48
T317	949	240	28
T318	889	435	41
T319	953	145	17
	Mean 887	Total 3 590	Total 353
T321	910	190	32
T322	839	480	61
T323	950	310	65
T324	884	265	40
T325	830	495	62
T326	827	385	49

Table J10: **Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).**

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
T327	860	490	69
T328	866	420	62
T329	953	295	58
	Mean 870	Total 3 330	Total 498
T351	871	290	34
T352	889	240	29
T353	905	280	38
T354	865	400	47
T355	895	300	39
T356	893	540	69
T357	922	405	56
T358	954	230	36
T359	849	255	26
	Mean 893	Total 2 940	Total 374
T411	1 045	150	39
T412	906	135	21
T413	1 037	125	33
T414	983	135	29
T415	831	115	13
T416	848	260	33
T417	911	185	29
T418	1 006	175	39
T419	1 019	280	69
	Mean 953	Total 1 560	Total 305
T421	1 080	45	12
T422	1 073	95	24
T423	998	80	15
T424	1 091	100	26
T425	1 000	75	14

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
T426	1 040	90	20
T427	1 074	100	26
T428	1 194	45	18
	Mean 1 063	Total 630	Total 155
T511	1 311	210	98
T512	1 225	95	42
T513	1 200	130	55
T514	1 046	195	52
T515	1 188	140	57
T516	992	145	33
T517	958	115	23
T518	966	230	47
T519	961	165	32
	Mean 1 090	Total 1 425	Total 439
T521	1 300	95	50
T522	1 047	185	52
T523	1 104	150	50
T524	925	100	18
T525	995	115	27
T526	1 072	130	39
T527	1 033	170	46
T528	1 010	230	57
T529	958	170	34
	Mean 1 040	Total 1 345	Total 373
T531	919	215	42
T532	875	160	26
T533	890	240	41
T534	846	230	33
T535	873	310	49

Table J10: Areas, mean annual precipitation and virgin mean annual runoff from Hydrological Research Unit (HRU) quaternary sub-catchments in Natal/KwaZulu (continued).

Quaternary sub-catchment code number	Mean annual precipitation (mm)	Gross/effective area (km^2)	Virgin mean annual runoff ($10^6 m^3$)
T536	900	115	20
T537	852	180	27
	Mean 878	Total 1 450	Total 238
T541	971	170	37
T542	928	85	16
T543	926	210	42
T544	957	195	41
T545	887	175	28
T546	878	85	14
T547	826	120	15
T548	804	80	9
T549	813	115	13
	Mean 900	Total 1 235	Total 215
T551	823	195	25
T552	841	225	31
T553	939	140	28
T554	889	275	45
T555	895	180	30
T556	855	140	20
T557	1 018	90	24
T558	953	45	10
	Mean 884	Total 1 290	Total 213

<u>Source</u>:

(i) After Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

(ii) After Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions

UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

(iii) After Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1983. An addendum to "Surface Water Resources of South Africa" (1981), Water Research Commission, Pretoria, various pages. (The virgin mean annual runoff (MAR) data for quaternary sub-catchments U111 - U409 inclusive, and sub-catchments V011 - V089 inclusive, were drawn from this publication and have been included in the table. Such data, as presented in Pitman et al (1981 - above), are incorrect).

Note:

(i) HRU tertiary catchment W34 does not exist.

(ii) Parts of quaternary sub-catchments or individual quaternary sub-catchments themselves, may lie outside Natal/KwaZulu. For example, quaternary catchments W461 - W465 are in Swaziland. Only W466 is in Natal/KwaZulu. Readers should consult maps showing the location of tertiary and quaternary catchments, found in the first two references (above).

(iii) Virgin runoff refers to catchments in a pristine state, prior to any land use changes which may have affected the hydrology. Quaternary virgin MARs were derived by proportional subdivision of the tertiary MARs. Synthetic monthly streamflow values for tertiary catchments are also presented in the first two references (above).

Table J11: Runoff equations for the ACRU runoff regions of Natal/KwaZulu.

ACRU runoff region	HRU hydro logical zone	HRU tertiary catchment	Runoff equation	Correlation coefficient	Number in sample
01	-	-	-	-	-
02	13b	W26/32/33/36/44/45/46B	$MAR = 1{,}84 \times 10^{0{,}00164\ MAP}$	0,984	27
03	13a	W35	$MAR = 1{,}62 \times 10^{0{,}00202\ MAP}$	0,999	4
04	8a	W31	$MAR = 2{,}81 \times 10^{0{,}00170\ MAP}$	0,993	7
05	8b	W24	$MAR = 2{,}85 \times 10^{0{,}00176\ MAP}$	0,983	8
06	8c	W25	$MAR = 2{,}08 \times 10^{0{,}00207\ MAP}$	0,988	8
07	5	W41/42/43	$MAR = 8{,}54 \times 10^{0{,}00142\ MAP}$	0,971	22
08	12	W21/22/23	$MAR = 2{,}49 \times 10^{0{,}00181\ MAP}$	0,985	22
09	7a	V08/W13/14	$MAR = 4{,}42 \times 10^{0{,}00146\ MAP}$	0,998	6
10	7b	W11/12/15	$MAR = 11{,}77 \times 10^{0{,}00108\ MAP}$	0,991	25

Table J11: Runoff equations for the ACRU runoff regions of Natal/KwaZulu (continued).

ACRU runoff region	HRU hydro logical zone	HRU tertiary catchment	Runoff equation	Correlation coefficient	Number in sample
11	10	V01B/02/03B/04/05/06/07B	MAR = 10,27 x $10^{0,00121\ MAP}$	0,941	8
12	6b	U11/13B/21/22/23B/30/40	MAR = 7,22 x $10^{0,00132\ MAP}$	0,997	7
13	3a	V01A	MAR = 37,79 x $10^{0,00083\ MAP}$	0,996	5
14	3b	U12/V03A/07A	MAR = 52,57 x $10^{0,00072\ MAP}$	0,999	5
15	2b	U23A	MAR = 20,81 x $10^{0,00096\ MAP}$	0,963	26
16	6a	U13A	MAR = 17,07 x $10^{0,00105\ MAP}$	0,950	14
17	2a	T51/52	MAR = 12,31 x $10^{0,00128\ MAP}$	0,993	17
18	1a	T41/53/54/55	MAR = 6,56 x $10^{0,00156\ MAP}$	0,968	33
19	3d	T35	MAR = 4,33 x $10^{0,00164\ MAP}$	0,972	9
20	3c	T31	MAR = 3,00 x $10^{0,00169\ MAP}$	0,995	9
21	1b	T42	MAR = 3,96 x $10^{0,00168\ MAP}$	0,997	8

__Source__: After Schulze, R.E., 1984. An assessment of the surface water resources of Natal, Natal Town and Regional Planning Commission Report, VOL 63, Pietermaritzburg, 44 p. and map.

__Note__: (i) Correlation coefficients are very high (all r>0,941 with 10>0,990). Accordingly, estimates of the MAR which are based on the calibrated Pitman Model simulations generated by the Hydrological Research Unit (briefly discussed a little later in the chapter), can be assumed to be realistic.

(ii) HRU tertiary catchment W34 does not exist.

(iii) HRU tertiary catchment T32 was not included in the study by Schulze (1984 - above).

(iv) MAP refers to mean annual precipitation.

10.4.1 __KwaZulu catchments__

The firm Eksteen Van der Walt and Nissen (1990) in an analysis of catchments in KwaZulu, divided the territory into 12 catchments on a priority basis (Table J12). Each catchment was given a three-digit number. The first digit indicates position from south to north - where 1 represents catchments in the south of KwaZulu; 2 represents the

Table J12: **KwaZulu catchments as determined by Eksteen Van der Walt and Nissen (EVN), 1990.**

EVN catchment code number	River catchment
110	uMvoti
120	uThongati/uMdloti
130	uMngeni
140	iLovu/uMlazi
150	uMkhomazi
160	uMzimkhulu
210	uThukela/Amatigulu
310	uMfolozi
320	uMhlathuze
410	uPhongolo
420	uMkhuze
430	iHluhluwe/iNyalazi

Source: After Anonymous, 1990. KwaZulu catchments development potential study 1990, VOL 1 - 3, various pages, and Appendix of maps, various pages, Eksteen Van der Walt and Nissen, Pietermaritzburg. (The report contains valuable data on a catchment-by-catchment basis, inter alia on soil types and soil erosion, surface runoff, veld types, water quality, sediment yield and groundwater sources in KwaZulu).

Tugela River catchment only; 3 represents the Mfolozi and Mhlatuze River catchments, while 4 denotes catchments in the north of KwaZulu. The second digit indicates defined river catchments, with the third digit consisting of a dummy number.

10.5 Homogeneous climate zones in Natal/KwaZulu

Dent, Lynch and Tarboton (1990)* reported on the delineation of 712 homogeneous climate zones in South Africa (see the chapter on rainfall), based on mean annual precipitation; altitude; aspect; geographic proximity; roughness of terrain, and the variety of agricultural activities. The homogeneous zones in Natal/KwaZulu are listed in Table

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* See Dent, M.C., Lynch, S.D. and Tarboton, H., 1990. Detailed delimitation of rainfall regions in southern Africa, Water SA, VOL 16(1), p. 1 - 4.

J13. Dent, Schulze and Angus (1988)* used the information to devise a localized areal method of soil moisture budgeting to determine inter alia, the runoff from dryland crops, as well as crop water requirements under irrigation. Selected data are presented in the latter report. A complete data-set is available from the Computing Centre for Water Research, University of Natal, Private Bag X01, Scottsville, 3209, showing the estimated water yield (surface and groundwater runoff) under given probabilities, for various soil depths and textures, in time steps of one month up to 12 months after planting, of specified crops for each homogeneous climate zone. Such data provide water resources information for the rapid initial assessment, for instance, of runoff into farm irrigation dams.

Table J13: Homogeneous climate zones in Natal/KwaZulu (north to south).

Zone
543 - 549
523 - 533
509 - 510
383 - 426
363 - 378
360
282 - 292
279 - 280
269 - 277
254

Source: After Dent, M.C., Schulze, R.E. and Angus, G.R., 1988. Crop water requirements, deficits and water yield for irrigation planning in southern Africa, WRC Report No. 118/1/88, Water Research Commission, Pretoria, 183 p. and map.

Note: The zones include that part of KwaZulu situated in the Transvaal and also the northern part of Transkei surrounded by Natal/KwaZulu. Some zones may include other land outside Natal/KwaZulu.

* See Dent, M.C., Schulze, R.E. and Angus, G.R., 1988. Crop water requirements, deficits and water yield for irrigation planning in southern Africa, WRC Report No. 118/1/88, Water Research Commission, Pretoria, 183 p. and map. (The publication includes a map of homogeneous climate zones in southern Africa).

10.6 Runoff models

Models are not discussed in any detail in this publication. Two of the runoff models used in South Africa to simulate yields are the ACRU (Agricultural Catchments Research Unit) Model developed at the Department of Agricultural Engineering, University of Natal, Pietermaritzburg (Schulze, 1989)*; and the Pitman Monthly Runoff Model (Pitman, 1973)** developed at the then Hydrological Research Unit of the University of the Witwatersrand. The Computing Centre for Water Research maintains a list of certain models used in South Africa for various hydrological, engineering, irrigation and water quality modelling purposes. Selected programs are available from the Centre. A recent report published by the Water Research Commission and the Department of Water Affairs and Forestry, contains a useful overview of some 62 models used in this country. Several other models are also listed***.

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* See Schulze, R.E., 1989. ACRU: background, concepts and theory, WRC Report No. 154/1/89, Water Research Commission, Pretoria, various pages, and Schulze, R.E., George, W.J., Lynch, S.D. and Angus, G.R., 1989. ACRU - 2.0: user manual, WRC Report No. 154/2/89, Water Research Commission, Pretoria, various pages. Note that the model has been revised and that updated documentation is available. See Schulze, R.E., 1995. Hydrology and agrohydrology: a text to accompany the ACRU 3.00 agrohydrological modelling system, WRC Report No. TT 69/95, Water Research Commission, Pretoria, various pages, as well as Smithers, J. and Schulze, R., 1995. ACRU agrohydrological modelling system: user manual version 3.00, WRC Report No. TT 70/95, Water Research Commission, Pretoria, various pages.

** See Pitman, W.V., 1973. A mathematical model for generating monthly river flows from meteorological data in South Africa, HRU Report No. 2/73, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, various pages. Note that the Pitman Model has been restructured. The updated version, the Water Resources Simulation Model (WRSM90) was written to run on a PC. (For an urban perspective see Green, I.R.A. and Stephenson, D., 1986. Urban hydrology and drainage: comparison of urban drainage models for use in South Africa, WRC Report No. 115/6/86, Water Research Commission, Pretoria, 265 p. + app., as well as Stephenson, D., Green, I.R.A. and Lambourne, J.J., 1986. Urban hydrology and drainage: review, WRC Report No. 115/1/86, Water Research Commission, Pretoria, 119 p. + app. An important series of 12 urban catchment publications (including the executive summary), is also available from the Water Research Commission, P O Box 824, Pretoria, 0001. An example is given here: Stephenson, D., 1993. Effects of urbanization on catchment water balance, 1. Analysis of effects of urbanization on runoff, WRC Report No. 183/1/93, Water Research Commission, Pretoria, 78 p.).

*** See CSIR Environmental Services, 1995. Procedures to assess effluent discharge impacts, WRC Report No. TT 64/94, Water Research Commission and the Department of Water Affairs and Forestry, Pretoria, 352 p.

10.7 Mean annual runoff in Natal/KwaZulu*

The mean annual runoff (MAR) in Natal/KwaZulu varies from less than 50 mm in the north east, to over 800 mm in the Drakensberg. If the 100 mm MAR is used as a threshold, then East Griqualand and almost the entire northern half of the province has relatively limited surface water resources. Some difficulties accordingly, may arise with longer term economic development in the northern half of the Tugela Basin, unless water is imported from further afield. The most severe shortage of surface water is found in the area bounded by Louwsburg, Ulundi, Mtubatuba, Ndumu and Ingwavuma. A large portion of the latter region produces an MAR of less than 50 mm, with a significant area yielding less than 15 mm MAR. For the north eastern part of Natal/KwaZulu where data are non-existent, Schulze (1984) estimated that the MAR would be less than 15 mm and certainly less than 50 mm.

10.8 Median monthly runoff in Natal/KwaZulu

Schulze (1984) found that there are considerable variations in runoff produced in different parts of Natal/KwaZulu in all months of the year. With the beginning of the rainy season, marked increases in runoff are evident during November and December. Over much of the province the highest flows occur during January to March, with the Drakensberg area yielding in excess of 60 mm of runoff in each of the months, January to March. The summer runoff in most other parts of Natal/KwaZulu is a steady 5 - 10 mm per month, with the north eastern part of Natal/KwaZulu producing less than 2,5 mm of runoff. It should be noted however, that during seven months of the year, the north eastern region produces less than 1 mm of runoff. Minimum flows in Natal/KwaZulu occur during August and September when most parts of the province yield less than 1 mm, with only a few isolated areas producing more than 5 mm of runoff.

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* Discussion based on Schulze, R.E., 1984. An assessment of the surface water resources of Natal, Natal Town and Regional Planning Commission Report, VOL 63, Pietermaritzburg, 44 p. and map. (Mean annual runoff was converted into a depth equivalent in mm for the purposes of the original discussion, by Schulze (1984)). Runoff data for individual rivers in Natal/KwaZulu are presented in the chapter on "estuaries", elsewhere in this publication.

10.9 The variability of monthly runoff in Natal/KwaZulu

An important trend observed by Schulze (1984) is that there is a high degree of variability of runoff for any given month, in most parts of Natal/KwaZulu. The variability is greatest in the north east and to a lesser extent in the north west during the months October to April (the period of greatest runoff production). The Tugela catchment in January, the Mfolozi Valley in February and the Drakensberg in August and September, all have a high runoff variability. Natal/KwaZulu, of all the provinces, has the lowest runoff variability and is in general known as the "Garden Province". For a discussion on drought runoff sequences in South Africa, see inter alia Midgley and Pitman (1969)*.

10.10 Water demand in Natal/KwaZulu

With the runoff data in mind, the following section provides information relating to water consumption and demand, firstly for primary drainage regions W, V, U and T (Tables J14 - J20). Overall demand statistics for South Africa and KwaZulu (Table J21), and for Natal/KwaZulu as a region (Table J22) are then outlined. Data in Tables J14 - J22 have been rounded off to the nearest whole number. Minor discrepancies may therefore be apparent.

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* See Midgley, D.C. and Pitman, W.V., 1969. Surface water resources of South Africa, HRU Report No. 2/69, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, 128 p. See also, Zucchini, W. and Adamson, P.T., 1984. Assessing the risk of deficiencies in streamflow, WRC Report No. 91/2/84, Water Research Commission, Pretoria, 41 p. + app., as well as Zucchini, W. and Adamson, P.T., 1984. The occurrence and severity of droughts in South Africa, WRC Report No. 91/1/84, 198 p. + app. and maps, and Appendix 6, WRC Report No. 91/1/84(A), various pages, Water Research Commission, Pretoria. See in addition, Schulze, R.E., 1979. Hydrology and water resources of the Drakensberg, Natal Town and Regional Planning Commission Report, VOL 42, Pietermaritzburg, 179 p.

Table J14: Mean annual surface runoff (natural MAR) and utilizable MAR for Natal/KwaZulu in 1980.

Primary drainage region	Surface MAR ($10^6 m^3$)	Utilizable MAR ($10^6 m^3$)	Utilizable % of MAR
W	5 894	3 484	59
V	4 589	3 310	72
U	3 174	2 563	81
T	8 501	5 104	60
Total	22 158	14 461	-

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note:

(i) Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

(ii) The utilizable percentage of MAR for all primary drainage regions in South Africa is 62%.

Table J15: Estimated mean annual groundwater abstraction for Natal/KwaZulu ($10^6 m^3$).

Primary drainage region	1980	1990	2000	2010
W	26	26	26	26
V	13	13	13	13
U	7	7	7	7
T	79	89	103	120
Total	125	135	149	166

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note:

(i) Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

(ii) The estimated volumes of groundwater which could be abstracted annually (under given limitations of economics and practicality) are respectively: 430 x $10^6 m^3$ with a total dissolved solids range of 200 - 2 500 mg ℓ^{-1} (W drainage region); 210 x $10^6 m^3$ in the range

400 - 1 500 mg ℓ^{-1} (V drainage region); 200 x $10^6 m^3$ in the range 200 - 1 000 mg ℓ^{-1} (U drainage region), and 460 x $10^6 m^3$ in the range 200 - 2 000 mg ℓ^{-1} (T drainage region).

Table J16: Estimated mean annual return flow for Natal/KwaZulu ($10^6 m^3$).

Primary drainage region	1980	1990	2000	2010
W	6	7	7	8
V	8	11	15	23
U	32	32	32	32
T	41	44	49	56
Total	87	94	103	119

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

Table J17: Estimated mean annual total available water (MAR + estimated return flow + estimated groundwater abstraction) for Natal/KwaZulu ($10^6 m^3$).

Primary drainage region	1980	1990	2000	2010
W	5 926	5 926	5 927	5 928
V	4 610	4 613	4 617	4 625
U	3 213	3 213	3 213	3 213
T	8 621	8 634	8 653	8 677
Total	22 370	22 386	22 410	22 443

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

Table J18: **Estimated mean annual total utilizable water (utilizable MAR + estimated return flow + estimated groundwater abstraction) for Natal/KwaZulu (10^6m^3).**

Primary drainage region	1980	1990	2000	2010
W	3 516	3 509	3 411	3 418
V	3 331	3 333	3 331	3 337
U	602	2 502	2 601	2 501
T	5 224	5 237	5 256	5 279
Total	14 673	14 581	14 599	14 535

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

Table J19: **Estimated mean annual intentional evaporation and disposal of poor quality water for Natal/KwaZulu (10^6m^3).**

Primary drainage region	1980	1990	2000	2010
W	18	26	27	27
V	25	26	26	27
U	7	7	7	7
T	3	3	3	4
Total	53	62	63	65

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

Table J20: Estimated annual water demand statistics for Natal/KwaZulu ($10^6 m^3$).

Primary drainage region	1980	1990	2000	2010
Urban and industrial water				
W	68	97	138	198
V	69	97	144	252
U	360	484	644	843
T	133	150	173	205
Total	630	828	1 099	1 498
Water for power generation				
W	0	0	0	0
V	12	12	121	12
U	0	0	0	0
T	0	0	0	0
Total	12	12	12	12
Water for mining				
W	3	4	4	5
V	7	7	8	8
U	3	4	6	7
T	0	0	0	0
Total	13	15	18	20
Water for irrigation on Government water schemes				
W	99	120	56	70
V	19	23	28	34
U	12	12	13	13
T	46	58	70	88
Total	176	213	167	205

Table J20: Estimated annual water demand statistics for Natal/KwaZulu (10^6m^3) (continued).

Primary drainage region	1980	1990	2000	2010
Water for irrigation under control of irrigation boards				
W	62	79	189	225
V	31	33	35	38
U	28	40	54	70
T	1	1	1	1
Total	122	153	279	334
Water for private irrigation				
W	500	542	588	643
V	152	194	239	292
U	240	326	420	525
T	111	119	124	129
Total	1 003	1 181	1 371	1 589
Total water demand for Government irrigation schemes, irrigation boards and private irrigation				
W	661	741	833	938
V	202	250	302	364
U	280	378	487	608
T	158	178	195	218
Total	1 301	1 547	1 817	2 128
Water for stock watering				
W	16	16	17	19
V	14	15	16	17
U	5	8	10	14
T	25	28	311	34
Total	60	67	74	84

Table J20: Estimated annual water demand statistics for Natal/KwaZulu ($10^6 m^3$) (continued).

Primary drainage region	1980	1990	2000	2010
Estimated reduction in runoff by forestry				
W	235	247	261	279
V	27	57	88	109
U	226	289	347	396
T	129	129	129	129
Total	617	722	825	913
Water for nature conservation				
W	5	5	5	5
V	0	0	0	0
U	0	0	0	0
T	0	0	0	0
Total	5	5	5	5
Water requirements for "estuaries" and lakes				
W	406	406	407	407
V	230	230	230	230
U	134	134	134	134
T	742	742	742	742
Total	1 512	1 512	1 513	1 513
Water requirements for environmental management (total of "estuaries", lakes and nature conservation)				
W	411	411	411	411
V	230	230	230	230
U	134	134	134	134
T	742	742	742	742
Total	1 517	1 517	1 517	1 517

Table J20: Estimated annual water demand statistics for Natal/KwaZulu ($10^6 m^3$) (continued).

Primary drainage region	1980	1990	2000	2010
Total water demand for Natal/KwaZulu				
W	1 394	1 516	1 664	1 850
V	561	668	800	992
U	1 008	1 297	1 628	2 002
T	1 187	1 227	1 270	1 328
Total	4 150	4 708	5 362	6 172

Source: After Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: (i) Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

(ii) There are currently (December 1993), no Government irrigation schemes - as components of formal Government water schemes - in Natal.

Table J21: Estimated annual water demand and surface runoff for South Africa and KwaZulu ($10^6 m^3$).

Water use	1980		1990		2000		2010	
	South Africa	KwaZulu	South Africa	KwaZulu	South Africa	KwaZulu	South Africa	KwaZulu
Domestic	1 040	35	1 576	53	2 236	78	3 104	131
Public	59	0	88	0	126	0	168	2
Industrial	899	3	1 293	5	1 838	8	2 680	16
Urban distribution losses	202	1	299	1	410	1	554	2
Total of municipal/ industrial use	2 200	39	3 256	59	4 610	87	6 506	151
Mining	394	0	433	0	493	0	545	0
Power stations	281	0	443	0	778	0	899	0
Irrigation (GWS)	1 951	0	2 329	22	2 732	37	2 900	52

Table J21: Estimated annual water demand and surface runoff for South Africa and KwaZulu ($10^6 m^3$) (continued).

Water use	1980		1990		2000		2010	
	South Africa	KwaZulu	South Africa	KwaZulu	South Africa	KwaZulu	South Africa	KwaZulu
Irrigation boards	2 168	0	2 495	0	2 884	0	3 099	0
Irrigation (private)	3 320	229	3 642	296	3 944	371	4 292	456
Stock watering	186	8	202	9	218	10	236	12
Nature conservation	176	2	180	2	185	2	189	2
"Estuaries" and lakes	2 033	35	2 032	35	2 032	35	2 032	35
Forestry	1 044	18	1 173	23	1 300	32	1 418	37
Other uses	39	0	39	0	39	0	39	0
Total	13 792	331	16 224	446	19 215	574	22 155	745
Surface runoff	34 231	3 584	34 231	3 584	34 231	3 584	34 231	3 584

Source: After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note:

(i) The abbreviation GWS refers to Government water schemes. There are currently (December 1993), no Government irrigation schemes - as components of formal Government water schemes - in Natal.

(ii) South Africa, as per Table J21, excludes the national states and the homelands.

Table J22: Estimated annual water demand for Natal/KwaZulu for 1980 and 2010 ($10^6 m^3$).

Sector	Direct use	%	1980				2010	
			Direct and indirect use (excluding ecological use)	%	Direct and indirect use (including ecological use)	%	Direct and indirect use (including ecological use)	%
Primary drainage region W								
Domestic	38	5	38	4	38	3	121	7
Industry	30	4	30	3	30	2	77	4
Mining	3	0	3	0	3	0	5	0
Power stations	0	0	0	0	0	0	0	0
Irrigation	661	88	661	67	661	48	938	51
Stock watering	16	2	16	2	16	1	19	1
Nature conservation	5	1	5	0	5	0	5	0
Total	753	100						
Forestry runoff reduction			235	24	235	17	279	15
Total			988	100				
"Estuaries" (provision)					406	29	406	22
Total					1 394	100	1 850	100
Primary drainage region V								
Domestic	33	11	33	10	33	6	122	12
Industry	36	12	36	11	36	7	130	13
Mining	7	2	7	2	7	1	8	1
Power stations	12	4	12	4	12	2	12	1
Irrigation	202	67	202	61	202	36	364	37
Stock watering	14	4	14	4	14	2	17	2
Nature conservation	0	0	0	0	0	0	0	0
Total	304	100						
Forestry runoff reduction			27	8	27	5	109	11
Total			331	100				
"Estuaries" (provision)					230	41	230	23
Total					561	100	992	100

Table J22: Estimated annual water demand for Natal/KwaZulu for 1980 and 2010 ($10^6 m^3$) (continued).

Sector	Direct use	%	1980				2010	
			Direct and indirect use (excluding ecological use)	%	Direct and indirect use (including ecological use)	%	Direct and indirect use (including ecological use)	%
Primary drainage region U								
Domestic	125	19	125	14	125	13	335	17
Industry	235	36	235	27	235	23	508	25
Mining	3	1	3	0	3	0	7	0
Power stations	0	0	0	0	0	0	0	0
Irrigation	280	43	280	32	280	28	608	30
Stock watering	5	1	5	1	5	1	14	1
Nature conservation	0	0	0	0	0	0	0	0
Total	648	100						
Forestry runoff reduction			226	26	226	22	396	20
Total			874	100				
"Estuaries" (provision)					134	13	134	7
Total					1 008	100	2 002	100
Primary drainage region T								
Domestic	50	16	50	11	50	4	121	9
Industry	83	26	83	19	83	7	84	6
Mining	0	0	0	0	0	0	0	0
Power stations	0	0	0	0	0	0	0	0
Irrigation	158	50	158	35	158	13	218	16
Stock watering	25	8	25	6	25	2	34	3
Nature conservation	0	0	0	0	0	0	0	0
Total	316	100						
Forestry runoff reduction			129	29	129	11	129	10
Total			445	100				
"Estuaries" (provision)					742	63	742	56
Total					1 187	100	1 328	100

Source: After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note: (i) Data for primary drainage regions W and T include areas outside Natal/KwaZulu.

(ii) Considerable debate surrounds the water allocation required for the environment. A useful synopsis of some relevant issues can be found in the following: Walmsley, R.D. and Davies, B.R., 1991. An overview of water for environmental management, Water SA, VOL 17(1), p. 67 - 76. (The paper discusses inter alia the Pongolo Floodplain and pans). See also Walmsley, J.J., 1995. Market forces and the management of water for the environment, Water SA, VOL 21(1), p. 43 - 50.

10.11 Sources of hydrological data

The Department of Water Affairs and Forestry, Private Bag X313, Pretoria, 0001, has runoff and other data for over 800 river gauging stations, as well as data for approximately 180 reservoirs and several lakes in South Africa*. When data are requested, the numbers of the required stations must be quoted (discussed later in the chapter). Failing that, the name of the nearest town, the name of the river/dam and the latitude and longitude co-ordinates of the site or area in question, should be provided. The data are in the form of computer print-outs, photocopies, floppy diskettes and magnetic tapes. (The latter two items must be supplied if such a data format is needed).

The streamflow data available in the Hydrological Information System (HIS) database include minimum and maximum daily flow; monthly flow; the monthly maximum flow peak, and the number of days per month that daily flow equalled or exceeded given values. Flow is also measured in canals and pipelines. Other data include reservoir/lake levels, inflows and volumes; station/catchment descriptions and inventories; plus weir design and calibration information, as well as water quality and climatological data (the latter discussed elsewhere in this volume). The publication, Anonymous, 1988. Availability of hydrological data, Hydrological Information Publication No. 14, Directorate of Hydrology, Department of Water Affairs, Pretoria, 11 p. + app., should be consulted for further information**. Two important references are Middleton, Lorentz, Pitman and Midgley

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* Sometimes referred to as the National River Gauging Network.

** See also Zietsman, D.P. and Schutte, J.M., 1981. The availability of quantitative and qualitative hydrological data, In: Hattingh, W.H.J. (ed), Water Year + 10 and Then?, Technical Report No. TR 114, Department of Water Affairs, Forestry and Environmental Conservation, Pretoria, p. 156 - 217.

(1981); and Pitman, Middleton and Midgley (1981)* which - besides maps - contain summaries of monthly totals of observed streamflow for specific catchments, as well as simulated streamflow for quaternary sub-catchments, mainly for a 55 year period up to 1975 (based on the Pitman Model). A further important reference is: Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages. (The book contains a wealth of material on water in South Africa and is a comprehensive reference work). Another useful reference is: Schulze, R.E., 1984. An assessment of the surface water resources of Natal, Natal Town and Regional Planning Commission Report, VOL 63, Pietermaritzburg, 44 p. and map. The publication contains several maps and diagrams, namely: hydrological response zones in Natal; mean annual runoff; areas with significant outliers of monthly runoff; median monthly flow for the hydrological year October - September; a monthly runoff variability index for the months October - September, and a map showing areas of low mean annual runoff.

The Computing Centre for Water Research, University of Natal, Pietermaritzburg, can supply (autographic gauge) runoff data for certain small research catchments, autographic data for selected storm events (runoff/rainfall), and mean annual series of flood peaks in

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* See Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, as well as Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg. The two reports are part of a six volume series. The entire set of six volumes (for the whole country) was reprinted in 1986 with several amendments. The series has been updated, and currently consists of six volumes - each comprising a set of appendices and a book of maps - with an overall user's manual. Data contained in the hard copy volumes are also available on CD-ROM. See: Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1994. Surface water resources of South Africa, 1990, VOL V: drainage regions M, N, P, Q, R, S, T. Eastern Cape - appendices, WRC Report No. 298/5.1/94, Water Research Commission, Pretoria, various pages, as well as Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1994. Surface water resources of South Africa, 1990, VOL V: drainage regions M, N, P, Q, R, S, T. Eastern Cape - book of maps, WRC Report No. 298/5.2/94, Water Research Commission, Pretoria, 30 p. and maps. See also Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1994. Surface water resources of South Africa, 1990, VOL VI: drainage regions U, V, W, X. Eastern escarpment - appendices, WRC Report No. 298/6.1/94, Water Research Commission, Pretoria, various pages, as well as Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1994. Surface water resources of South Africa, 1990, VOL VI: drainage regions U, V, W, X. Eastern escarpment - book of maps, WRC Report No. 298/6.2/94, Water Research Commission, Pretoria, 30 p. and maps. Refer in addition to Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1994. Surface water resources of South Africa, 1990: user's manual, WRC Report No. 298/1/94, Water Research Commission, Pretoria, various pages. (Note that a complete listing of all the reports can be found on the inside front cover of any given report. Nearly all maps in the books of maps are at a scale of 1 : 1 000 000. Each book of maps contains a base map indicating catchment boundaries, rivers, major dams and towns; as well as information on rainfall (stations, zones and isohyets); evaporation (stations, zones and isolines); runoff (stations, zones, isolines and endoreic areas); land cover (minor dams and afforested/irrigation areas); streamflow modelling (model parameters); geology; soils; sediment yield and vegetation).

large catchments data. The Centre is linked to the HIS database of the Department of Water Affairs and Forestry. Access to WATERLIT - the water literature database established by the Division of Information Services, CSIR, P O Box 395, Pretoria, 0001, is also possible via the Centre.

Other sources of data which may not necessarily be available on the HIS/Computing Centre for Water Research network, are listed as footnotes to Table J24 (see later in this chapter). See also: James, A.G. and Fuller, H.L.M., 1987. Register of southern African hydrological data sources, South African Water Information Centre, CSIR, Pretoria, 287 p. Several documents containing hydrological data are listed below.

<u>Some publications containing hydrological data and information</u>*

<u>Department of Water Affairs and Forestry reports and associated documents</u>

- Anonymous, 1978. River flow data: monthly summaries October 1960 to September 1970, Hydrological Information Publication No. 10, Division of Hydrology, Department of Water Affairs, Pretoria, 550 p.

- Anonymous, 1978. Reservoir inflow records: monthly summaries up to September 1970, Hydrological Information Publication No. 11, Division of Hydrology, Department of Water Affairs, Pretoria, 168 p.

- Jordaan, J.M., 1964. Monthly flow records of gauging stations up to September 1960, VOL 1: comprising records of gauging stations main drainage regions 100 - 500, Hydrographic Survey Publication No. 8, Division of Hydrological Research, Department of Water Affairs, Pretoria, 464 p.

- Jordaan, J.M., 1968. Monthly flow records of gauging stations up to September 1960, VOL 2: comprising records of gauging stations main drainage regions 600 - 2200, Hydrographic Survey Publication No. 8, Division of Hydrological Research, Department of Water Affairs, Pretoria, 528 p.

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* Further reports can be found in the bibliographic database. The sources listed mainly concern measured (observed) data. A considerable proportion of runoff data is generated by using various models.

- Middleton, B.J. and Pitman, W.V., 1984. Surface water resources of South Africa: the 1981 appraisal, Civil Engineer in South Africa, VOL 26(7), p. 323 - 332. (And discussion, VOL 27(8), 1985, p. 449 - 452).

- Midgley, D.C. and Pitman, W.V., 1969. Surface water resources of South Africa, HRU Report No. 2/69, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, 128 p. (This report was subsequently updated by the six volume series first published in 1981, and referred to in the preceding discussion).

- Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1983. An addendum to "Surface Water Resources of South Africa" (1981), Water Research Commission, Pretoria, various pages.

- Midgley, D.C., Pitman, W.V. and Middleton, B.J., 1983. A guide to "Surface Water Resources of South Africa", (1981) and its Addendum (1983), Water Research Commission, Pretoria, various pages. (The guide and the addendum provide further useful information inter alia on legal aspects of water, warnings to users, other examples of problem solving, flow duration curves and evaporation data, as well as corrections).

University hydrological data and reports

- Barnes, P.M. and Hope, A.S., 1980. Processed hydrological records from selected catchments W1M15, W1M16 and W1M17, November 1976 to February 1980, Zululand Hydrology Project Report No. 1/80, Hydrological Research Unit, University of Zululand, KwaDlangezwa, 105 p.

- Bodenstein, B. and Kelbe, B., 1991. Processed runoff data: Ntuze catchment weirs W1H016 and W1H031, 1990, HRU Report No. 1/91, Hydrological Research Unit, University of Zululand, KwaDlangezwa, 17 p. + app.

- Hope, A.S. and Mulder, G.J., 1979. Hydrological investigations of small catchments in the Natal coastal belt and the role of physiography and land-use in the rainfall-runoff process, Publication Series B2, University of Zululand, KwaDlangezwa, 283 p. (The publication includes a 1 : 18 000 scale soil map of the Ntuze catchment).

- Hutchison, I.P.G., 1974. St Lucia Lake and Estuary - hydrographic data, HRU Report No. 3/74, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, 82 p. and map.

- Hutchison, I.P.G. and Pitman, W.V., 1973. St Lucia Lake research report, VOL 1: Climatology and hydrology of the St Lucia Lake system, HRU Report No. 1/73, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, 111 p.

- Kelbe, B., 1989. Processed hydrological data: station 304622: University of Zululand Campus, 1988, HRU Report No. 1/89, Hydrological Research Unit, University of Zululand, KwaDlangezwa, 27 p. + app.

- Kelbe, B., 1990. Processed hydrological data: station 304622: University of Zululand Campus, 1989, HRU Report No. 1/90, Hydrological Research Unit, University of Zululand, KwaDlangezwa, 14 p. + app.

- Kelbe, B., 1990. Processed runoff data: Ntuze catchment weirs W1H016 and W1H031, 1989, HRU Report No. 5/90, Hydrological Research Unit, University of Zululand, KwaDlangezwa, 13 p. + app.

- Kelbe, B. and Rawlins, B., 1990. Processed hydrological data for St Lucia Eastern Shores Forest Reserve, 1989, HRU Report No. 2/90, Hydrological Research Unit, Department of Hydrology, University of Zululand, KwaDlangezwa, 14 p. + app.

- Kelbe, B.E. and Rawlins, B.K., 1990. Environmental impact assessment of the hydrological response to proposed dredge mining of the dunes along the Eastern Shores of Lake St Lucia, HRU Report No. 4/90, Department of Hydrology, University of Zululand, KwaDlangezwa, 84 p.

- Pitman, W.V. and Hutchison, I.P.G., 1975. A preliminary hydrological study of Lake Sibaya, HRU Report No. 4/75, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, 35 p. + app.

- Rivett-Carnac, A.S. and Schulze, R.E., 1977. Simulated streamflows in the Umfolozi catchment, ACRU Report No. 4, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 42 p.

- Schmidt, E.J. and Schulze, R.E., 1989. The Cedara hydrological research catchments 1974 to 1989, ACRU Report No. 34, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 95 p.

- Schmidt, E.J. and Schulze, R.E., 1989. The De Hoek/Ntabamhlope hydrological research catchments 1974 to 1989, ACRU Report No. 33, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 110 p.

- Schulze, R.E., 1977. Processed hydrological records from selected catchments in Natal, ACRU Report No. 3, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 79 p.

- Schulze, R.E., 1981. Estimations of storm runoff and sediment yield for selected small dam sites in KwaZulu, ACRU Report No. 12, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 75 p.

- Schulze, R.E., 1985. The De Hoek and Ntabamhlope hydrological research catchments: excursion guide, ACRU Report No. 21, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 52 p.

- Schulze, R.E. and Dent, M.C., 1982. Hydrological design information for water resources development from small dams in the Highflats area, ACRU Report No. 13, Agricultural Catchments Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 47 p.

- Schulze, R.E. and Engelbrecht, K.M., 1978. Processed hydrological records from selected catchments in Natal, VOL 2, ACRU Report No. 5, Agricultural Catchments

Research Unit, Department of Agricultural Engineering, University of Natal, Pietermaritzburg, 146 p.

Other reports

- Anonymous, 1961. Water resources and water requirements within the Umgeni River catchment, Natal Town and Regional Planning Commission Report, VOL 7, Pietermaritzburg, 22 p. + app.

- Chew, J.A. and Bowen, 1965. The water resources of the Illovo River: a preliminary survey of the Illovo River and its water storage possibilities, Natal Town and Regional Planning Commission Report, VOL 12, Pietermaritzburg, 37 p. + app.

- Chew, J.A. and Bowen, 1971. The water resources of the coastal areas of northern Natal and Zululand, Natal Town and Regional Planning Commission Report, VOL 17, Pietermaritzburg, 18 p. + app.

- James, W., 1973. Storage of water on the Zululand coastal plains: a brief study of the feasibility of conserving runoff from the lower-lying parts of most Natal catchments, and of distributing the water from a storage area in Zululand to coastal demand centres, Natal Town and Regional Planning Commission Report, VOL 22, Pietermaritzburg, 57 p.

- Matthews, P.E., 1969. Diversion of water to the upper region of the Tugela Basin: a study of the three-dimensional structure of the Tugela River system and its hydrological and geological significance, Natal Town and Regional Planning Commission Report, VOL 16, Pietermaritzburg, 30 p.

- Ninham Shand and Partners, 1971. Water resources of the Natal South Coast, Natal Town and Regional Planning Commission Report, VOL 18A, 31 p. + app., and VOL 18B, Appendices, various pages, Pietermaritzburg.

- Schulze, R.E., 1979. Hydrology and water resources of the Drakensberg, Natal Town and Regional Planning Commission Report, VOL 42, Pietermaritzburg, 179 p.

- Thomas, W.M., 1951. Part 2. Chapter 4. Some aspects of water resources in Natal, In: Burrows, H.R. (ed), Natal Regional Survey, VOL 1: Archaeology and Natural Resources of Natal, Oxford University Press, Cape Town, p. 112 - 135. (The chapter provides brief, historical data on gauging stations including runoff, catchment area and geology).

- Thorrington-Smith, E., 1953. Tugela Basin: a regional survey of the catchment area of the Tugela River and its tributaries, Natal Town and Regional Planning Commission Interim Report, Pietermaritzburg, 143 p. and maps.

- Thorrington-Smith, E., 1960. Towards a plan for the Tugela Basin: second interim report of the regional survey of the Tugela Basin, prepared in the Office of the Town and Regional Planning Commission, Natal, Natal Town and Regional Planning Commission Report, VOL 5, Pietermaritzburg, 266 p. and maps.

- Thorrington-Smith, Rosenberg and McCrystal, 1978. Towards a plan for KwaZulu: a preliminary development plan, VOL 1, The written report, 341 p., and VOL 2, Atlas of maps and illustrations, various pages, KwaZulu Government, Ulundi.

10.12 Department of Water Affairs and Forestry hydrological gauging station reference system and network

The reference numbers of hydrological gauging stations consist of alpha-numerical characters. A typical reference number, for example, U2H011 is indicative of several parameters:

(a) The first alphabetical character identifies the main (primary) drainage region, for example, where U indicates the Mkomaas/Mgeni River drainage region.

(b) The second character is the second last digit of the secondary drainage region, namely, the 2 from 1920, the Mgeni River catchment area.

(c) The third character is an alphabetical character which indicates the type of gauging station as shown in Table J23.

(d) The rest of the reference number indicates the chronological order in which the gauging stations in that particular sub-drainage region were opened, namely, the 11th station.

It should be noted that the reference system of flow (and other) gauging stations was changed in 1989. Previously the letter "M" was used. This has been replaced by "HO". For example, U2M27 is now U2H027. Further changes are reflected in Table J24, which provides a listing of gauging stations in Natal/KwaZulu.

Table J23: Types of gauging stations/points maintained by the Department of Water Affairs and Forestry.

Type	Example of number
Primary type Flowing water stations (rivers, springs, etc.)	U2<u>H</u>011
Stored/standing water stations (reservoirs, lakes and dams)	U2<u>R</u>005
Meteorological stations - mainly evaporation (indicates evaporation measured using a <u>Class A</u> <u>pan</u>, a <u>Symons</u> <u>pan</u>, air temperature and <u>precipitation</u> measured at that point. Note: Weather Bureau stations are provided with a Weather Bureau number, for example, 370/807 at Chelmsford Dam. Not all stations have a Weather Bureau number, as in the example where there is no such number)	U2<u>E</u>005 - A01; A02 - S01 - P01
Secondary type A01 (indicates upstream gauge plate for H and R stations)	T4H001 - A01
B01 (indicates downstream gauge plate for H and R stations)	T5H003 - B01
C01 (indicates crest tapping on crump weirs - where no inlet pipes are found)	None in Natal/KwaZulu
H01 (indicates opening sizes of dam gates)	V1R002 - H01
K01 (indicates opening sizes of valves at dams)	V1R002 - K01
M01 (indicates a pipeline meter to determine flow rate)	U3H007 - M01
Q01 (indicates a water quality sampling point)	T5H005 - Q01

Table J23: Types of gauging stations/points maintained by the Department of Water Affairs and Forestry (continued).

Type	Example of number
R01 (indicates a water quality sampling point for raw water only, for example, at a water purification works)	V3H021 - R01
S01 (indicates a water quality sampling point for treated water only, for instance, at a water purification works)	V3H021 - S01
U01 (indicates a slope survey section with respect to floods)	None in Natal/KwaZulu
V01 (indicates a velocity measurement section, measured using current meters)	U8H001 - V01
W01 (indicates float velocity measurements using floats)	U4H005 - W01
Z01 (indicates combined flow data for several stations/points)	V1R002 - Z01

<u>Source</u>: (i) After Zietsman, D.P. and Schutte, J.M., 1981. The availability of quantitative and qualitative hydrological data, In: Hattingh, W.H.J. (ed), Water Year + 10 and Then?, Technical Report No. TR 114, Department of Water Affairs, Forestry and Environmental Conservation, Pretoria, p. 156 - 217.

(ii) After the Department of Water Affairs and Forestry, Durban, 1993.

<u>See also</u>: (i) Lotriet, H.H. and Rooseboom, A., 1995. River discharge measurement in South African rivers: the development of improved measuring techniques, WRC Report No. 442/2/95, Water Research Commission, Pretoria, various pages.

(ii) McDonald, R.D., 1989. Nuwe nommers vir meetstasies, meetpunte en stelsels sowel as vir data en inligting, Technical Report No. TR 141, Department of Water Affairs, Pretoria, 43 p. + app.

(iii) Rossouw, J., Rooseboom, A. and Wessels, P., 1995. Laboratory calibration of compound sharp-crested and crump weirs, WRC Report No. 442/1/95, Water Research Commission, Pretoria, 53 p. + app.

(iv) Van Heerden, J.J., Van der Spuy, D. and Le Roux, P.J., 1986. Manual for the planning, design and operation of river gauging stations, Technical Report No. TR 126, Department of Water Affairs, Pretoria, 153 p. + app.

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
T3			
T3H004	Mzintlava River at Kokstad	30°34′	29°25′
T3H008	Mzimvubu River at Inungi	30°34′	29°09′
T4			
T4H001	Mtamvuna River at Gundrift	30°44′	29°49′
T5			
T5H001	Mzimkulu River at Umzimkulu	30°15′	29°56′
T5H002	Bisi River at Nooitgedacht	30°24′	29°54′
T5H003	Polela River at Himeville	29°44′	29°32′
T5H004	Mzimkulu River at The Banks	29°46′	29°28′
T5H005	Nkonzo River at Kleinhoek	29°59′	29°51′
T5H006	Mzimkhulwana River at Oribi Gorge	30°42′	30°16′
T5H007	Mzimkulu River at Bezweni	30°14′	29°55′
T5H008	Mvubukazi River at Embetyuleni	30°16′	29°24′
T5H009	Ngwangwane River at Standfords Drift	29°53′	29°24′
T5H010	Left canal on Mzimkulu River at Bezweni	30°14′	29°55′
T5H011	Pipeline from Mvubukazi River at Embetyuleni	30°16′	29°24′
T5H012	Mzimkhulwana River at Gilbert Eyles Dam	30°43′	30°09′
U1			
U1H001	Mkomazi River at Bridley Manor	30°00′	30°14′
U1H002	Mkomazi River at Bartman	29°53′	30°04′
U1H003	Mkomazi River at Umkomazi Drift	30°08′	30°46′
U1H004	Mkomazi River at Umkomazi Drift	30°08′	30°46′
U1H005	Mkomazi River at Camden	29°44′	29°54′
U1H006	Mkomazi River at Delos Estate	30°10′	30°41′
U1H007	Pipeline from Mkomazi River at Umkomazi Drift	30°08′	30°46′
U2			
U2H001	Mgeni River at Howick	29°29′	30°14′
U2H002	Mgeni River at Inanda Location	29°39′	30°48′
U2H003	Mgeni River at KwaDabeka	29°45′	30°56′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
U2H004	Mgeni River at Nagle Dam	29°35′	30°35′
U2H005	Mgeni River at Nagle Dam	29°35′	30°35′
U2H006	Karkloof River at Shafton	29°22′	30°16′
U2H007	Mpofana River at Weltevreden	29°26′	30°09′
U2H008	Mabane River at Henley Dam	29°37′	30°16′
U2H009	Tenjaan River at Henley Dam	29°37′	30°14′
U2H010	Msindusaan River at Henley Dam	29°37′	30°14′
U2H011	Msunduze River at Henley Dam	29°38′	30°15′
U2H012	Sterk River at Groothoek	29°26′	30°29′
U2H013	Mgeni River at Petrus Stroom	29°30′	30°07′
U2H014	Mgeni River at Albert Falls Dam	29°25′	30°25′
U2H015	Mgeni River at Inanda Location	29°41′	30°49′
U2H016	Rietspruit tributary 1 at Cedara	29°33′	30°14′
U2H017	Rietspruit at Cedara	29°33′	30°15′
U2H018	Rietspruit at Cedara	29°34′	30°14′
U2H019	Rietspruit tributary 2 at Cedara	29°32′	30°16′
U2H020	Rietspruit tributary 3 at Cedara	29°32′	30°16′
U2H021	Cramond River at Cramond	29°25′	30°25′
U2H022	Msunduze River at Inanda Location	29°39′	30°38′
U2H023	Darvill Sewage Works at Pietermaritzburg	29°36′	30°25′
U2H024	Palmiet River at Pinetown	29°48′	30°52′
U2H025	Palmiet River at Pinetown	29°49′	30°53′
U2H026	Palmiet River at Pinetown	29°48′	30°51′
U2H027	Palmiet River tributary at Woodside	29°48′	30°54′
U2H028	Palmiet River at Westville	29°49′	30°54′
U2H029	Palmiet River tributary at Pinetown	29°48′	30°52′
U2H030	Palmiet River at Westville	29°49′	30°57′
U2H031	Palmiet River at Westville	29°49′	30°57′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
U2H032	Mbongokazi River at Westville	29°48′	30°57′
U2H033	Palmiet River tributary at Westville	29°49′	30°57′
U2H034	Palmiet River at Westville	29°48′	30°57′
U2H035	Mgeni River at Springfield Flats	29°48′	30°30′
U2H036	Palmiet River tributary at Cowies Hill	29°49′	30°54′
U2H037	Mgeni River at Midmar Dam	29°29′	30°09′
U2H038	Nculwane River at Albert Falls	29°24′	30°22′
U2H039	Doringspruit at Albert Falls	29°27′	30°20′
U2H040	Mgeni River at Albert Falls	29°26′	30°19′
U2H041	Msunduze River at Hamstead Park	29°36′	30°27′
U2H042	Mngeweni River at Inanda Location	29°39′	30°41′
U2H043	Mgeni River at Nagle Dam	29°35′	30°37′
U2H044	Umthinzima River at Rietvallei	29°33′	30°11′
U2H045	Nguku River at Grootvlei	29°32′	30°10′
U2H046	KwaGqushi River at Ashley Grange	29°32′	30°07′
U2H047	Dorpspruit at Pietermaritzburg	29°36′	30°24′
U2H048	Mgeni River at Midmar Dam	29°29′	30°12′
U2H049	Pipeline from Midmar Dam	29°29′	30°12′
U2H050	Blackhurst pump at Midmar Dam	29°29′	30°12′
U2H051	Ross pump at Midmar Dam	29°29′	30°12′
U2H052	Mgeni River at Nagle Dam	29°35′	30°37′
U2H053	Pipeline from Nagle Dam	29°35′	30°37′
U2H054	Mgeni River at Inanda Mission Reserve	29°42′	30°52′
U2H055	Mgeni River at Inanda Location	29°38′	30°41′
U3 U3H001	Tongati River at Riet Kuil	29°32′	31°05′
U3H002	Mdloti River at Hazelmere Dam	29°36′	31°01′
U3H003	Mdloti River at Hazelmere Dam	29°36′	31°00′
U3H004	Left canal from Tongati River at Riet Kuil	29°32′	31°05′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
U3H005	Mdloti River at Hazelmere Dam	29°36′	31°02′
U3H006	Left pipeline from Hazelmere Dam	29°36′	31°02′
U3H007	Right pipeline from Hazelmere Dam	29°36′	31°02′
U4 U4H001	Mvoti River at Stanger	29°21′	31°14′
U4H002	Mvoti River at Mistley	29°09′	30°37′
U4H003	Hlimbitwa River at Boschfontein	29°00′	30°47′
U4H004	Nseleni River at Boschfontein	29°01′	30°46′
U4H005	Mvoti River at Glenmill	29°17′	31°07′
U4H006	Mvoti River at Eglington	29°17′	31°11′
U4H007	Mvoti River at Glendale	29°17′	31°07′
U4H008	Left canal from Mvoti River at Glendale	29°17′	31°07′
U6 U6H001	Mlazi River at Lamontville	29°57′	30°57′
U6H002	Mlazi River at Nooitgedacht	29°44′	30°19′
U6H003	Mlazi River at Umlaas	29°48′	30°30′
U6H004	Mlazi River at Shongweni Dam	29°51′	30°42′
U6H005	Sterkspruit at Shongweni Dam	29°51′	30°42′
U6H006	Wekeweke River at Shongweni Dam	29°50′	30°43′
U6H007	Pipeline from Shongweni Dam	29°50′	30°43′
U7 U7H001	Zwateni River at Highlands Estate	29°51′	30°14′
U7H002	Lovu River at Illovo	30°05′	30°49′
U7H003	Lovu River tributary 1 at Deep Dene	29°50′	30°16′
U7H004	Lovu River tributary 2 at Deep Dene	29°50′	30°16′
U7H005	Lovu River tributary 3 at Deep Dene	29°50′	30°16′
U7H006	Lovu River tributary 4 at Deep Dene	29°50′	30°15′
U7H007	Lovu River at Beaulieu Estate	29°51′	30°14′
U7H008	Nungwana River at Nungwane Dam	30°00′	30°44′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
U7H009	Pipeline from Nungwane Dam	30°00′	30°44′
U7H010	Umgababa River at Umgababa Dam	30°08′	30°48′
U7H011	Pipeline from Umgababa Dam	30°08′	30°48′
U8			
U8H001	Fafa River at Never Despair	30°23′	30°36′
U8H002	Mtwalume River at Umtwalumi Mission	30°27′	30°33′
U8H003	Mpambanyoni River at Umbeli Belli	30°16′	30°41′
V1			
V1H001	Tugela River at Colenso	28°44′	29°49′
V1H002	Tugela River at Bergville	28°44′	29°21′
V1H003	Ndumeni River tributary 2 at Cathkin Peak	28°59′	29°13′
V1H004	Mlambonjwa River at The Delta	28°47′	29°18′
V1H005	Masongwane River tributary 4 at Cathedral Peak	28°59′	29°14′
V1H006	Masongwane River tributary 1 at Cathedral Peak	28°58′	29°14′
V1H007	Masongwane River tributary 3 at Cathedral Peak	28°59′	29°14′
V1H008	Masongwane River tributary 4 at Cathedral Peak	28°59′	29°14′
V1H009	Bloukrans River at Frere	28°53′	29°46′
V1H010	Little Tugela River at Winterton	28°49′	29°32′
V1H011	Bloukrans River tributary 11 at De Hoek Research Station	29°00′	29°37′
V1H012	Bloukrans River tributary 12 at De Hoek Research Station	29°00′	29°38′
V1H013	Bloukrans River tributary 15 at De Hoek Research Station	29°01′	29°38′
V1H014	Bloukrans River tributary 16 at De Hoek Research Station	29°01′	29°38′
V1H015	Bloukrans River tributary 9 at De Hoek Research Station	29°00′	29°38′

Table J24: **Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).**

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V1H016	Bloukrans River tributary 10 at De Hoek Research Station	29°00′	29°38′
V1H017	Bloukrans River tributary 13 at De Hoek Research Station	29°01′	29°39′
V1H018	Bloukrans River tributary 1 at De Hoek Research Station	29°00′	29°40′
V1H019	Bloukrans River tributary 4 at De Hoek Research Station	29°00′	29°40′
V1H020	Bloukrans River tributary 14 at De Hoek Research Station	29°01′	29°40′
V1H021	Masongwane River tributary 7 at Cathedral Peak	28°59′	29°15′
V1H022	Masongwane River tributary 6 at Cathedral Peak	28°59′	29°15′
V1H023	Mhlwazini River tributary 9 at Cathedral Peak	28°59′	29°16′
V1H024	Mhlwazini River tributary 10 at Cathedral Peak	28°59′	29°15′
V1H025	Ndedema River tributary 8 at Cathedral Peak	28°59′	29°16′
V1H026	Tugela River at Kleine Waterval	28°43′	29°21′
V1H027	Bloukrans River tributary 7 at De Hoek Research Station	29°00′	29°38′
V1H028	Bloukrans River tributary 14A at De Hoek Research Station	29°02′	29°40′
V1H029	Geluksburgspruit at Schoonspruit	28°30′	29°20′
V1H030	Njongola River at Strydhoek	28°30′	29°20′
V1H031	Sandspruit at Bergville	28°43′	29°21′
V1H032	Putterillspruit at Wan Hoop	28°38′	29°02′
V1H033	Tugela River at Clifford Chambers	28°39′	29°02′
V1H034	Khombe River at Groot Geluk	28°40′	29°05′
V1H035	Tugela canal at Second [?]	28°40′	29°07′
V1H036	Jagersrust-forebay at Jagersrust Pump Station	29°36′	29°07′
V1H037	Mnweni River at Isandhlwana	28°48′	29°10′

Table J24: **Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).**

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V1H038	Klip River at Ladysmith	28°33′	29°45′
V1H039	Little Tugela River at Drakensberg Location 2	29°03′	29°31′
V1H040	Tuva canal at Woodstock	28°43′	29°14′
V1H041	Mlambonjwa River at Kleinerivier	29°48′	29°18′
V1H042	Ndumeni River tributary 11 at Cathedral Peak	29°00′	29°15′
V1H043	Ndumeni River tributary 12 at Cathedral Peak	29°00′	29°14′
V1H044	Ndumeni River tributary 13 at Cathedral Peak	29°00′	29°14′
V1H045	Ndumeni River tributary 14 at Cathedral Peak	29°00′	29°14′
V1H046	Ndumeni River tributary 15 at Cathedral Peak	28°59′	29°14′
V1H047	Mdwaleni River at Driel Barrage	28°45′	29°17′
V1H048	Tugela River at Clifford Chambers	28°38′	29°04′
V1H049	Tugela River at Spioenkop Dam	28°44′	29°21′
V1H050	Venterspruit at Action Valley	28°37′	29°24′
V1H051	Klip River at Ladysmith Mosque	28°34′	29°46′
V1H052	Right canal from Putterillspruit at Wan Hoop	28°38′	29°02′
V1H053	Right canal from Tugela River at Clifford Chambers	28°39′	29°02′
V1H054	Right canal from Little Tugela River at Winterton	28°44′	29°49′
V1H055	Right canal from Khombe River at Groot Geluk	28°40′	29°05′
V1H056	Right canal from Gelukburgspruit at Schoonspruit	28°30′	29°20′
V1H057	Tugela River at Spioenkop Dam	28°40′	29°31′
V1H058	Tugela River at Driel Barrage	28°45′	29°17′
V1H059	River sluice gates at Spioenkop Dam	28°40′	29°31′
V1H060	Pipeline to Ladysmith at Spioenkop Dam	28°40′	29°31′
V1H061	Pipeline to Jagersrust at Driel Barrage	28°45′	29°17′
V1H062	Pipeline to Jagersrust at Driel Barrage	28°45′	29°17′
V1H063	Pipeline from dam to river at Driel Barrage	28°45′	29°17′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V1H064	Left canal from Little Tugela canal at Winterton	28°44′	29°49′
V2 V2H001	Mooi River at Scheepersdal	29°01′	30°21′
V2H002	Mooi River at Mooi River	29°13′	29°59′
V2H003	Mnyamvubu River at Bloemendal	29°13′	30°15′
V2H004	Mooi River at Doornkloof	29°04′	30°14′
V2H005	Mooi River at Avon	29°21′	29°52′
V2H006	Little Mooi River at Dartington	29°15′	29°52′
V2H007	Hlatikulu River at Broadmoor	29°14′	29°47′
V2H008	Mooi River at Keate's Drift	28°51′	30°30′
V2H009	Mooi River at Mearns	29°14′	29°58′
V2H010	Mnyamvubu River at Craigieburn Dam	29°10′	30°16′
V2H011	Mpateni River at Craigieburn Dam	29°10′	30°17′
V2H012	Rietvleispruit at Craigieburn Dam	29°11′	30°16′
V2H013	Mooi River at Mooi River	29°13′	29°59′
V2H014	Weir outlet to Mooi River at Mearns	29°14′	29°58′
V2H015	Pipeline to Lions River at Mearns	29°14′	29°58′
V2H016	Mnyamvubu River at Craigieburn Dam	29°09′	30°17′
V2H017	Lower outlet from Craigieburn Dam	29°09′	30°17′
V2H018	Highest outlet from Craigieburn Dam	29°09′	30°17′
V3 V3H001	Buffalo River at St Peter's Mission	28°14′	30°30′
V3H002	Buffalo River at Schurvepoort	27°36′	29°56′
V3H003	Ngagane River at Ballengeich	27°55′	29°57′
V3H004	Horn River at Ballengeich	27°53′	29°58′
V3H005	Slang River at Vlakdrift	27°26′	29°58′
V3H006	Buffalo River at De Jagersdrift	28°00′	30°23′
V3H007	Ncandu River at Rust	27°50′	29°50′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V3H008	Dorps River at Weltevreden	27°38′	30°20′
V3H009	Horn River at Ballengeich	27°53′	29°57′
V3H010	Buffalo River at Tayside	28°03′	30°22′
V3H011	Blood River at Bembaskop	27°53′	30°34′
V3H012	Fouriespruit at Sleutelpoort	28°04′	29°52′
V3H013	Mahlomyane River at Doornpoort	28°03′	29°50′
V3H014	Ngagane River at Nooitgedacht	28°04′	29°47′
V3H015	Buffalo River at Vaalbank	27°44′	30°12′
V3H016	Klipspruit at Normandien	27°59′	29°46′
V3H017	Spectaclespruit at Chelmsford Dam	27°57′	29°53′
V3H018	Ngagane River at Chelmsford Dam	27°56′	29°56′
V3H019	Manzamnyama River at Lilydale	28°04′	29°55′
V3H020	Kalbas River at Lilydale	28°03′	29°57′
V3H021	Ngagane Purification Works	27°47′	28°59′
V3H022	Buffalo River at Ngagane	27°43′	30°04′
V3H023	Ngagane River at Parklands	27°43′	30°04′
V3H024	Ngagane River at Parklands	27°43′	30°03′
V3H025	ESKOM pipeline from Chelmsford Dam	27°57′	29°56′
V3H026	Department of Water Affairs and Forestry pipeline from Chelmsford Dam	27°57′	29°56′
V3H027	Ngagane River at Chelmsford Dam	27°57′	29°56′
V3H028	Slang River at Zaaihoek Dam	27°26′	30°03′
V3H029	Pipeline from Zaaihoek Dam	27°26′	30°03′
V3H030	Buffalo River at Schurvepoort	27°36′	29°56′
V3H031	Pipeline from Buffalo River at Ngagane Purification Works	27°36′	29°56′
V3H032	Left canal from Dorps River at Weltevreden	27°36′	29°56′
V5			
V5H001	Tugela River at Mandini	29°10′	31°23′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V5H002	Tugela River at Mandini	29°08′	31°23′
V6			
V6H001	Tugela River at Impafana Location	28°44′	30°21′
V6H002	Tugela River at Tugela Ferry	28°45′	30°26′
V6H003	Wasbank River at Kuikvlei	28°18′	30°08′
V6H004	Sundays River at Kleinfontein	28°24′	30°00′
V6H005	Tugela River at Impafana Location	28°44′	30°19′
V6H006	Sundays River at Waterfall	28°14′	29°45′
V6H007	Tugela River at Impafana Location	28°44′	30°22′
V6H008	Right canal from Tugela River at Impafana Location	28°44′	30°21′
V7			
V7H001	Bushmans River at Estcourt	29°00′	29°53′
V7H002	Little Bushmans River tributary 29 at Ntabamhlope Research Station	29°02′	29°39′
V7H003	Little Bushmans River tributary 18 at Ntabamhlope Research Station	29°02′	29°39′
V7H004	Little Bushmans River tributary 25 at Ntabamhlope Research Station	29°03′	29°39′
V7H005	Little Bushmans River tributary 19 at Ntabamhlope Research Station	29°02′	29°39′
V7H006	Little Bushmans River tributary 20 at Ntabamhlope Research Station	29°02′	29°39′
V7H007	Little Bushmans River tributary 21 at Ntabamhlope Research Station	29°02′	29°38′
V7H008	Little Bushmans River tributary 24 at Ntabamhlope Research Station	29°03′	29°39′
V7H009	Little Bushmans River tributary 26 at Ntabamhlope Research Station	29°02′	29°38′
V7H010	Little Bushmans River tributary 28 at Ntabamhlope Research Station	29°02′	29°39′
V7H011	Little Bushmans River tributary 23 at Ntabamhlope Research Station	29°03′	29°39′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
V7H012	Little Bushmans River at Estcourt	29°00′	29°52′
V7H013	Little Bushmans River tributary 27 at Ntabamhlope Research Station	29°02′	29°38′
V7H014	Little Bushmans River tributary 30 at Ntabamhlope Research Station	29°02′	29°38′
V7H015	Little Bushmans River tributary 31 at Ntabamhlope Research Station	29°02′	29°39′
V7H016	Ncibidwane River at Drakensberg Location 1	29°11′	29°38′
V7H017	Bushmans River at Drakensberg Location 1	29°11′	29°38′
V7H018	Little Bushmans River at Craig	29°04′	29°44′
V7H019	Bushmans River at Dalton Bridge	29°05′	29°48′
V7H020	Bushmans River at Wagendrift Dam	29°02′	29°51′
V7H021	Pipeline (Chatwick) at Wagendrift Dam	29°02′	29°51′
V7H022	Pipeline (Parks Board) at Wagendrift Dam	29°02′	29°51′
V7H023	Pipeline (Drummond) at Wagendrift Dam	29°02′	29°51′
V7H024	Pipeline (Parks Board) at Wagendrift Dam	29°02′	29°51′
V7H025	Pipeline from Wagendrift Dam to Estcourt	29°02′	29°51′
W1			
W1H001	Mhlatuze River at Magdale	28°39′	31°37′
W1H002	Mfule River at Native Reserve 11	28°46′	31°28′
W1H003	Inkwalini River at Nkwalini	28°43′	31°30′
W1H004	Mlalazi River at Eshowe	28°52′	31°27′
W1H005	Mfulazane River at Golden Reef	28°34′	31°23′
W1H006	Mhlatuze River at Normanhurst	28°46′	31°28′
W1H007	Matigulu River at Amatikulu	29°03′	31°31′
W1H008	Mhlatuze River at Lower Nkwalini	28°42′	31°48′
W1H009	Mhlatuze River at Riverview	28°44′	31°44′
W1H010	Matigulu River at Native Reserve 21	29°00′	31°27′
W1H011	Msingazi River at Arboretum (Lake Mzingazi)	28°46′	32°04′
W1H012	Ntuze River at Ngoye	28°54′	31°47′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
W1H013	KwaGugushe River at Ngoye	28°50′	31°47′
W1H014	Ntuze River at Ngoye	28°51′	31°13′
W1H015	Amanzamnyama River at Ngoye	28°52′	31°46′
W1H016	KwaGugushe River at Ngoye	28°50′	31°46′
W1H017	KwaGugushe River at Ngoye	28°50′	31°45′
W1H018	Manzamnyama River at The Ranch(e)	28°58′	31°44′
W1H019	Siyaya River at The Ranch(e)	28°58′	31°44′
W1H020	Mfule River at Quneba	28°42′	31°39′
W1H021	Mhlatuze River at Ngoye	28°50′	31°52′
W1H022	Mbabe River at Nseleni	28°41′	32°01′
W1H023	Nseleni River at Eseleni Reserve	28°41′	32°00′
W1H024	Mhlatuze River at Naauwkloof	28°33′	31°09′
W1H025	Mlalazi River tributary at Eshowe	28°52′	31°27′
W1H026	Right canal from Mfulazane River at Golden Reef	28°34′	31°23′
W1H027	Right canal from Mhlatuze River at Normanhurst	28°46′	31°28′
W1H028	Mhlatuze River at Goedertrouw Dam	28°46′	31°28′
W1H029	Left canal from Goedertrouw Dam	28°46′	31°28′
W1H030	Right canal from Goedertrouw Dam	28°46′	31°28′
W2 W2H001	Mfolozi River at Riverview	28°26′	32°09′
W2H002	Black Mfolozi River at Umfolozi Game Reserve	28°18′	31°54′
W2H003	White Mfolozi River at Umfolozi Game Reserve	28°20′	31°51′
W2H004	Mfolozi River at Riverview	28°27′	32°10′
W2H005	White Mfolozi River at Ulundi	28°20′	31°22′
W2H006	Black Mfolozi River at Native Reserve 12	28°04′	31°33′
W2H007	Bizamkulu River at Ekuhlengeni	27°57′	31°11′
W2H008	Black Mfolozi River at Ekuhlengeni	27°56′	31°12′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
W2H009	White Mfolozi River at Doornhoek	27°53′	30°53′
W2H010	Mfolozi River at Native Reserve 5	28°27′	32°08′
W2H011	White Mfolozi River at Klipfontein	27°50′	30°48′
W2H012	White Mfolozi tributary at Vryheid Bridge	27°46′	30°46′
W2H013	Black Mfolozi tributary at Boschhoek	27°49′	31°07′
W2H014	Black Mfolozi tributary at Riversdale	27°48′	31°06′
W2H015	Black Mfolozi River at Bloemendal	27°49′	31°05′
W2H016	Black Mfolozi River at Aloeboom	27°49′	31°06′
W2H017	Black Mfolozi River at Rendsburg	27°51′	31°08′
W2H018	Black Mfolozi River at Brakfontein	27°52′	31°11′
W2H019	Mgobhozi River at Brakfontein	27°52′	31°11′
W2H020	Hlonyane River at Waterval	27°59′	31°05′
W2H021	Vuna River at Inuna Bridge	27°59′	31°36′
W2H022	White Mfolozi River at Klipstapel	28°12′	31°01′
W2H023	Mbhekamuzi River at KwaMeke Bridge	28°07′	31°29′
W2H024	Black Mfolozi River at Mwaka weir	28°03′	31°24′
W2H025	Black Mfolozi River at Native Reserve 12	28°11′	31°44′
W2H026	Mona River at Native Reserve 12	28°09′	31°47′
W2H027	White Mfolozi River at Okuku Railway Bridge	28°23′	31°41′
W2H028	Black Mfolozi River at Ekuhlengeni	27°56′	31°12′
W2H029	Right canal from Bizamkulu River at Ekuhlengeni	27°57′	31°11′
W2H030	White Mfolozi River at Klipfontein Dam	27°50′	30°47′
W3 W3H001	Mkuze River at Rietboklaagte	27°40′	31°40′
W3H002	Mkuze River at Morgenstond (Mkuze Bridge)	27°35′	32°00′
W3H008	Mkuze River at Doornhoek	27°36′	31°57′
W3H009	Pipeline from Hluhluwe Dam	28°07′	32°10′
W3H010	Mbazwana River at Mbazwana	27°29′	32°35′

Table J24: **Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).**

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
W3H011	Mkuze River at Morrisvale (Lower Mkuze)	27°39′	32°25′
W3H012	Mzinene River at Cloete	27°51′	32°21′
W3H013	Nyalazi River at Cekeni	28°10′	32°20′
W3H014	Mpate River at Mpate Forest Reserve	28°19′	32°21′
W3H015	Hluhluwe River at False Bay (St Lucia)	28°02′	32°21′
W3H016	Mkuze Swamp at Mbazwane Pan	27°42′	32°32′
W3H017	Mkuze Swamp at Demezane canal	27°46′	32°30′
W3H018	Mkuze Swamp at Flying boat section	27°48′	32°30′
W3H019	Mkuze River at Ontevrede	27°41′	31°12′
W3H020	Mkuze River at Verdrukt	27°40′	31°26′
W3H021	Hluhluwe River at Hluhluwe Game Reserve	28°08′	32°01′
W3H022	Hluhluwe River at Hluhluwe Dam	28°07′	32°10′
W4			
W4H001	Pongola River at Mwutshini	27°25′	31°37′
W4H002	Pongola River at Intulembi	27°21′	31°55′
W4H003	Pongola River at Grootdraai	27°25′	31°30′
W4H004	Bivane River at Pivaansbad	27°31′	30°51′
W4H005	Ngwavuma River (Swaziland)	27°04′	31°50′
W4H006	Pongola River at M'hlati	27°21′	31°47′
W4H007	Pongola River at Makane's Drift	27°01′	32°18′
W4H008	Braksloot at Pongola	27°23′	31°38′
W4H009	Pongola River at Ndumu Game Reserve	26°54′	32°19′
W4H010	Pongola River at Ndumu (Kangazini)	27°02′	32°16′
W4H011	Pongola River at Mvutshini Estate	27°25′	31°37′
W4H012	Right canal from Pongola River at Grootdraai	27°25′	31°30′
W4H013	Pongola River at Pongolapoort Dam	27°25′	32°04′
W4H014	Right canal from Pongolapoort Dam	27°25′	32°04′
Dams/lakes			
T5R001	Gilbert Eyles Dam (Mzimkhulwana River)	30°43′	30°09′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
T5R002	Singisi Dam (Singisi River)	30°15′	29°31′
U2R001	Midmar Dam (Mgeni River)	29°29′	30°12′
U2R002	Nagle Dam (Mgeni River)	29°35′	30°37′
U2R003	Albert Falls Dam (Mgeni River)	29°25′	30°25′
U2R004	Inanda Dam (Mgeni River)	29°42′	30°52′
U2R005	Henley Dam (Msunduze River)	29°37′	30°14′
U3R001	Hazelmere Dam (Mdloti River)	29°36′	31°02′
U6R001	Shongweni Dam (Mlazi River)	29°51′	30°43′
U7R001	Umgababa Dam (Umgababa River)	30°08′	30°48′
U7R002	Nungwane Dam (Nungwana River)	30°00′	30°44′
U8R001	Mzinto Dam (Mzinto River)	30°18′	30°35′
V1R001	Spioenkop Dam (Tugela River)	28°40′	29°31′
V1R002	Driel Barrage (Tugela River)	28°45′	29°17′
V1R003	Woodstock Dam (Tugela River)	28°45′	29°14′
V1R004	Kilburn Dam (Mnjaneni River)	28°35′	29°06′
V2R001	Craigieburn Dam (Mnyamvubu River)	29°09′	30°17′
V3R001	Chelmsford Dam (Ngagane River)	27°57′	29°56′
V3R002	Amcor Dam (Ncandu River)	27°44′	29°59′
V3R003	Zaaihoek Dam (Slang River)	27°26′	30°03′
V7R001	Wagendrift Dam (Bushmans River)	29°02′	29°51′
W1R001	Goedertrouw Dam (Mhlatuze River)	28°46′	31°28′
W1R002	Eshowe Dam (Mlalazi River)	28°52′	31°27′
W1R003	Lake Nsezi	28°45′	31°57′
W1R004	Lake Mzingazi	28°46′	32°04′
W2R001	Klipfontein Dam (White Mfolozi River)	27°50′	30°47′
W3R001	Hluhluwe Dam (Hluhluwe River)	28°07′	32°10′
W3R002	Lake St Lucia	27°58′	32°23′
W4R001	Pongolapoort (Jozini) Dam (Pongola River)	27°25′	32°04′

Table J24: Department of Water Affairs and Forestry flow gauging stations in Natal/KwaZulu, 1993 (south to north) (continued).

Department of Water Affairs and Forestry station number	Site and place name	Co-ordinates	
		latitude S	longitude E
W7R001	Lake Sibayi	27°25′	32°41′
W7R002	Lake Mgobezeleni	27°32′	32°39′
W7R003	Kosi Lake (Kuhlange) at Maklangula jetty	26°57′	32°49′
W7R004	Lake Makhawulani (middle of Kosi Lake) at KwaMazambane	26°55′	32°51′

<u>Source</u>: (i) After Anonymous, 1990. List of hydrological gauging stations July 1990, VOL 1: gauging stations in flowing water, Hydrological Information Publication No. 15, Directorate of Hydrology, Department of Water Affairs, Pretoria, 443 p.

(ii) After Anonymous, 1990. List of hydrological gauging stations July 1990, VOL 2, Part 1: gauging stations in stored/standing water, 177 p., and Part 2: meteorological stations, 153 p., Hydrological Information Publication No. 15, Directorate of Hydrology, Department of Water Affairs, Pretoria.

(iii) After the Department of Water Affairs and Forestry, Durban, 1993.

<u>Note</u>: (i) Only the primary installation at a given site is listed. Readers requiring older data are referred to publications outlined elsewhere in this chapter.

(ii) The following stations were closed at various times (up to and including 1993). Specific dates of closure for each station can be obtained from the Department of Water Affairs and Forestry, P O Box 1018, Durban, 4000, or Private Bag X313, Pretoria, 0001. See also, Source (i) above.

Station closed	Station closed
T5	V2H010 - V2H011
T5H006	V2H013
U1	V2H017 - V2H018
U1H001 - U1H004	**V3**
U1H007	V3H001
U2	V3H003 - V3H006
U2H001 - U2H004	V3H008

Station closed	Station closed
U2H008 - U2H010	V3H011
U2H015	V3H021
U2H038 - U2H040	V3H025
U2H044 - U2H046	V3H030
U2H050 - U2H052	V3H032
U3 U3H001 - U3H002	**V5** V5H001
U3H004	**V6** V6H001
U4 U4H001	V6H005
U4H003 - U4H008	V6H007
U6 U6H001	**V7** V7H001 - V7H002
U6H004 - U6H006	V7H005 - V7H006
U7 U7H002 - U7H006	V7H008 - V7H009 V7H013 - V7H015
U7H010 - U7H011	V7H024
U8 U8H002 - U8H003	**W1** W1H001 - W1H003
V1 V1H001	W1H007 - W1H010 W1H014
V1H004	W1H018 - W1H022
V1H011 - V1H014	W1H024 - W1H027
V1H016 - V1H019 V1H027	**W2** W2H001 - W2H004
V1H029 - V1H030	W2H008
V1H032	W2H010
V1H034	W2H012
V1H036	W2H021
V1H048	W2H023
V1H050	W2H026 - W2H027

Station closed	Station closed
V1H052 - V1H053	**W3**
V1H055 - V1H056	W3H001 - W3H002
V1H059	W3H010 - W3H013
V1H063	W3H016 - W3H018
V2 V2H001	**W4** W4H001 - W4H002
V2H003	W4H007 - W4H008
V2H008	W4H010

(iii) Three stations were opened after 1990, as indicated.

Station opened		Co-ordinates	
		latitude S	longitude E
U2 U2H057	Slangspruit at Pietermaritzburg (Umgeni Water station 15/6/1992)	29°38′	30°21′
U4 U4H009	Mvoti River at Melville (27/2/1992)	29°23′	31°15′
W2 W2H031	Pipeline from Klipfontein Dam (1/3/1993)	30°47′	21°21′

(iv) The following secondary drainage region codes apply to the stations listed in Table J24:

Station	Drainage region	Station	Drainage region
T3H004; T3H008	1830	W3H001 - W3H022 (excluding unallocated numbers W3H003 - W3H007 inclusive)	2130
T4H001	1840		
T5H001 - T5H012	1850	W4H001 - W4H014	2140/2141/2144/2145
U1H001 - U1H007	1910	T5R001; T5R002	1850
U2H001 - U2H055	1920	U2R001; U2R002; U2R003; U2R004; U2R005	1920
U2H057	1920 (excluding unallocated number U2H056)		
U3H001 - U3H007	1930	U3R001	1930
U4H001 - U4H009	1940	U6R001	1960
U6H001 - U6H007	1960	U7R001; U7R002	1970
U7H001 - U7H011	1970	U8R001	1980
U8H001 - U8H003	1980	V1R001; V1R002; V1R003; V1R004	2010
V1H001 - V1H064	2010	V2R001	2020
V2H001 - V2H018	2020	V3R001; V3R002; V3R003	2030
V3H001 - V3H032	2030	V7R001	2070
V5H001 - V5H002	2050	W1R001; W1R002; W1R003; W1R004	2111/2112
V6H001 - V6H008	2060	W2R001	2121
V7H001 - V7H025	2070	W3R001; W3R002	2130
W1H001 - W1H030	2111/2112/2113	W4R001	2144
W2H001 - W2H031	2121/2122/2123	W7R001; W7R002; W7R003; W7R004	2170

(v) The Department of Agricultural Engineering, University of Natal, Pietermaritzburg, maintains its own research gauge network in the De Hoek/Ntabamhlope and Cedara catchments. The Department of Hydrology, University of Zululand, KwaDlangezwa, likewise has research gauges in the Ntuze River catchment. The South African Sugar Association Experiment Station similarly, has a research gauge network at La Mercy. A research network was also recently established in the Sezela catchment. The Division of Forest Science and Technology, CSIR, has research gauges in the Cathedral Peak catchment.

(vi) The Department of Water Affairs and Forestry produces a weekly report on the volume of water available in the 139 major storage dams of South Africa. In Natal/KwaZulu the dams reported on are: Albert Falls; Chelmsford; Craigieburn; Driel; Goedertrouw; Hazelmere; Hluhluwe; Inanda; Klipfontein; Midmar; Nagle; Pongolapoort (Jozini); Spioenkop; Wagendrift; Woodstock, and Zaaihoek. Data expressed as a percentage of the nett full supply capacity, are also provided on the volume of water found in the given dam during the previous week, and for the same period in the previous year. Example: Anonymous, 1994. Department of Water Affairs and Forestry: weekly state of reservoirs as on 1994/01/03, Department of Water Affairs and Forestry, Pretoria, no pagination. The information is especially useful for drought studies. It would appear that the publication began in January 1983.

10.13 Aspects of runoff data for Natal/KwaZulu

An analysis of streamflow data for South Africa in 1980 (Table J25), revealed that very few rivers in Natal/KwaZulu have long term records. Many data records in South Africa generally, are incomplete, while land use changes in catchments over time - as well as faulty equipment plus other factors - may result in difficulties with the reliability of streamflow data. This is particularly the case for the identification of cycles and for the accurate assessment of water resources. Various methods are available to "patch" data.

Problems with the limited distribution of gauges are also apparent, especially in mountain catchments of the High Drakensberg (Cathedral Peak excepted), major rivers draining into "estuaries", and the drier areas of northern KwaZulu (as well as other parts of KwaZulu). Swart and Allanson (1988)* observed that only eight out of 73 rivers in Natal/KwaZulu

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* See Swart, D.H. and Allanson, B.R., 1988. Chapter 5. River flows and estuaries. Estuaries, In: Macdonald, I.A.W. and Crawford, R.J.M. (eds), Long-term Data Series Relating to Southern Africa's Renewable Natural Resources, South African National Scientific Programmes Report No. 157, Foundation for Research Development, CSIR, Pretoria, p. 201 - 210.

Table J25: Number of stations with various lengths (years) of streamflow data for catchments of given size in South Africa, 1980.

Province	Area (km^2)	Length of record (years)			
		>75	50 - 74	25 - 49	<25
Natal/KwaZulu	<10	0	0	11	2
	10 - 100	0	0	3	5
	101 - 1 000	1	2	22	10
	>1 000	0 (1)	0 (2)	12 (48)	10 (35)
Transvaal	<10	1	0	3	3
	10 - 100	0	2	8	24
	101 - 1 000	1	3	29	21
	>1 000	1 (3)	3 (8)	18 (58)	11 (59)
Cape	<10	0	0	9	14
	10 - 100	0	1	21	38
	101 - 1 000	0	3	15	48
	>1 000	0 (0)	9 (13)	7 (52)	24 (124)
Orange Free State	<10	0	0	1	1
	10 - 100	0	0	3	0
	101 - 1 000	0	3	6	9
	>1 000	3 (3)	10 (13)	4 (14)	11 (21)
Total		7	36	172	239 (231)

__Source__: After Schulze, R.E. and Scott, D.F., 1988. Chapter 5. River flows and estuaries. Surface water hydrology, In: Macdonald, I.A.W. and Crawford, R.J.M. (eds), Long-term Data Series Relating to Southern Africa's Renewable Natural Resources, South African National Scientific Programmes Report No. 157, Foundation for Research Development, CSIR, Pretoria, p. 183 - 200.

__Note__: There is an apparent summation error for the <25 years category in Natal/KwaZulu.

have streamflow gauges situated within 20 km of the coast, resulting in difficulties in evaluating river flow into estuaries. Furthermore, 59 of the 73 rivers draining into estuaries have no streamflow gauges at all. The Division of Earth, Marine and Atmospheric Science and Technology, CSIR, P O Box 320, Stellenbosch, 7599, accordingly provided simulated monthly virgin runoff data (at the mouth) for 69 rivers in Natal/KwaZulu draining into estuaries. The data-span covered the years 1921 - 1975. The runoff data were derived from reports produced by the then Hydrological Research Unit, University of the Witwatersrand*. For further details see Perry (1986)**.

10.14 International rivers of Natal and environs***

Recommendations drawn up by the International Law Association in Helsinki in 1966 (known as the Helsinki Rules), concern the joint use of water common to two or more states****. The Helsinki Rules define an international drainage basin (also termed an international watercourse system) as a geographical area extending over two or more states; and which is determined by the watershed limits of the system of waters - including surface and groundwaters - flowing into a common terminus. A basin state (also known as a system state), is defined as a state whose territory includes a portion of an international drainage basin. Each basin state is entitled (within its territory), to a reasonable and equitable share of the water of an international drainage basin which can be beneficially used. The principle of equitable sharing implies that the maximum benefit with the minimum disadvantage should accrue to each basin state, following from the use of the common water. This does not mean that every state must necessarily receive an

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* See Middleton, B.J., Lorentz, S.A., Pitman, W.V. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL V: drainage regions MNPQRST. The eastern Cape Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 12/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg, as well as Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg.

** See Perry, J.E., 1986. Basic physical geography/hydro data for Natal "estuaries", NRIO Data Report No. D 8607, Sediment Dynamics Division, Coastal Engineering and Hydraulics, National Research Institute for Oceanology, CSIR, Stellenbosch, 6 p. + app.

*** Discussion based on Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

**** An interesting sub-discipline is that of "hydropolitics" namely, the study of political interactions between countries, especially in water-scarce regions. There are those who believe that future wars - in certain parts of the world - will be fought over water.

equal share in the use of the water, where the economic and social needs of individual basin states must be taken into account for the purposes of water allocation. The Helsinki Rules also make provision for the control of water pollution, and for the settling of disputes.

South Africa has used the Helsinki Rules as a basis for water agreements between Botswana, Swaziland, Mozambique, Lesotho, Zimbabwe, Namibia, the Transkei, the Ciskei, Bophuthatswana and Venda, as well as the (self governing) homeland areas. With reference to Natal, Joint Permanent Technical Committees on water have been established for South Africa and Lesotho; South Africa and Swaziland, and South Africa and Mozambique. A Tripartite Technical Committee operates with regard to South Africa, Swaziland and Mozambique (Table J26). Also in Natal, the Republic of South Africa-KwaZulu Permanent Water Commission, involving the Department of Water Affairs and Forestry, operates in conjunction with the KwaZulu authorities. Various joint basin studies have been undertaken in Natal/KwaZulu (see the bibliographic database). A similar body, the Republic of South Africa-Transkei Permanent Water Commission, is involved with rivers in southern Natal.

A Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region was signed in August 1995 by Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. The aim of the Protocol is to promote the integrated management and equitable utilization of water resources in shared drainage basins of the SADC countries, with a view inter alia to economic cooperation.

Table J26: International rivers of Natal/KwaZulu.

River	Country
Drainage regions W10 - W70 Assegaai	
Bivane	
Black Mfolozi	
Kosi Bay	South Africa/Mozambique
Matigulu	
Mhlatuze	

Table J26: International rivers of Natal/KwaZulu (continued).

River	Country
Mkuzi	
Mlalazi	
Ngwavuma	South Africa/Swaziland
Pongola	South Africa/Swaziland
Usuthu	South Africa/Swaziland/Mozambique
White Mfolozi	
Drainage regions V10 - V70	
Bloukrans	
Buffalo	
Bushmans	
Klip	
Lower Tugela	
Middle Tugela	
Mlambonjwa	
Mnweni	
Mooi	
Sundays	
Upper Tugela	
Drainage regions U10 - U80	
Lovu	
Mdloti	
Mgeni	
Mkomanzi	
Mlazi	
Mtwalume	
Mvoti	
Nonoti	
Drainage regions T10 - T90	
Mtamvuna	South Africa/Transkei
Mzimkulu	South Africa/Transkei
Mzimvubu	South Africa/Transkei

Source: (i) After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

(ii) After the Department of Water Affairs and Forestry, Durban, 1993.

See also: (i) Anonymous, 1986. Republic of South Africa: agreement in respect of a servitude to be granted by Swaziland to South Africa for the inundation of 3 800 acres (1 540 hectares) in Swaziland by the Pongolapoort Dam and instruments of ratification thereto, Treaty Series No. 10/1986, Government Printer, Pretoria, 7 p.

(ii) Anonymous, 1986. Republic of South Africa: agreement between the Government of the Kingdom of Swaziland, the Government of the People's Republic of Mozambique and the Government of the Republic of South Africa relative to the establishment of a Tripartite Permanent Technical Committee, Treaty Series No. 12/1986, Government Printer, Pretoria, 4 p. (The treaty deals with the establishment of a committee to administer joint water schemes, rivers of common interest and related matters).

(iii) Anonymous, 1987. Republic of South Africa: multilateral agreement on the control of pollution of water resources in the southern African region, Treaty Series No. 9/1987, Government Printer, Pretoria, 15 p.

(iv) Kriel, J.P., 1979. Report of the Interdepartmental Committee Concerning the Division of Water Between the Black States, the Remainder of the Republic of South Africa and the Republics of Bophuthatswana and Transkei, Report No. RP 109/1979, Government Printer, Pretoria, 227 p. and maps.

Note: Unless otherwise indicated, rivers listed in the table refer to agreements between South Africa (Natal) and KwaZulu.

10.15 Some voluntary river catchment and similar organizations in Natal/KwaZulu

The relevant data are outlined in Table J27. Detailed local information on environmental river conditions may be obtained inter alia by contacting the organizations listed. Catchment management is increasingly being viewed in terms of an overall strategy which is aimed at management of the catchment as a unit, by involving all Interested and Affected Parties. The new procedure is known as Integrated Catchment Management (ICM). An example is the Karkloof River Integrated Catchment Management Project, the details of which are currently being finalized. Relevant parties include land owners, the Department of Water Affairs and Forestry, Umgeni Water, and the Wildlife Society of

Table J27: Some voluntary river catchment and similar organizations in Natal/KwaZulu, 1993.

Organization	Address
Devonshire Avenue Conservancy	c/o J. Hooker, 1 Devonshire Avenue, Howick, 3290
Sappi-Saiccor Ltd (Umkomaas Estuary)	c/o The Environmentalist, P O Box 62, Umkomaas, 4170
Siyaya Catchment Association	c/o I. Garland, P O Box 83, Mtunzini, 3867
Tugela Basin Development Association	P O Box 22, Colenso, 3360
Ubombo-Ingwavuma Regional Development Planning Committee	c/o KwaZulu Department of Economic Affairs, 367 Loop Street, Pietermaritzburg, 3201
Umkomaas River Conservation Trust	c/o C. De Rauville, P O Box 730, Durban, 4000
Umtamvuna River Trust	c/o T. Abbott, P O Box 111, Port Edward, 4295
Umzumbe Conservancy	c/o D. Campbell, P O Box 6, Umzumbe, 4225
Upper Tugela Catchment Committee	c/o Natal Agricultural Union, P O Box 186, Pietermaritzburg, 3200
Wasbank River Management Committee	c/o T. Roberts, Natal Parks Board, P O Box 425, Dundee, 3000
Zinkwazi Conservancy	c/o B. Hagemann, P O Box 68, Darnall, 4480

Source: (i) Fieldwork.

(ii) After the Natal Parks Board, Durban, 1993.

See also: Robertson, T.C., 1960. The South African river catchment associations, South African Journal of Science, VOL 56(4), p. 93 - 96. (The paper provides a useful historical perspective).

Note: (i) Some of the organizations were established for reasons other than river management per se, but have subsequently included such activities or interests within their spheres of operation. (An example is the Umzumbe Conservancy). The active state of the various organizations may vary with regard to river and other water issues.

(ii) Irrigation boards and (soil) conservation committees for instance, the Umvoti Conservation Committee, also undertake certain river conservancy functions. The Umvoti Conservation Committee has organized the removal of alien plant species from the watercourses and riparian zones of the Heine/Dorpspruit, a major source of water for Merthley Dam and accordingly, for Greytown. Indigenous species have been planted in the riparian zones (Anonymous, 1993)*. In a few cases river catchment associations have subsequently evolved into irrigation boards, while in other cases, river catchment associations have become defunct (for example, the Umgeni Catchment Association).

(iii) The South African Rivers Association, P O Box 583, Constantia, 7848 (involved with the use of rivers for recreation), while not a scientific body, has a considerable interest in the maintenance of river systems and the prevention of environmental degradation.

(iv) Other organizations of relevance (mainly in terms of the educational aspects of rivers) are the following: GREEN** (Global Rivers Environmental Education Network), c/o R. O'Donoghue, Natal Parks Board, P O Box 662, Pietermaritzburg, 3200; Project Water, c/o Umgeni Water, P O Box 9, Pietermaritzburg, 3200; Renfreight/ Rennies Wetlands Campaign, c/o Natal Parks Board, P O Box 17090, Congella, 4013, and Share-Net (Umgeni Valley Nature Reserve/Project), P O Box 394, Howick, 3290.

Southern Africa (the promoters of the Karkloof project) (Cooper, 1996)***. The Karkloof River is an important tributary of the Mgeni River. The ecosystem health of the Karkloof River is accordingly essential for the proper functioning of the Albert Falls Dam in particular. The Karkloof catchment has a variety of land uses ranging from natural grasslands and wetlands to commercial forestry plantations, and is a generally scenic and well conserved area. There are a number of privately owned protected zones such as the Leopards Bush Private Nature Reserve, and the Umgeni Valley Nature Reserve/Project run by the Wildlife Society. Maintenance of the rich biodiversity of the area (the presence of timber plantations notwithstanding), is of considerable environmental and hydrological significance. It follows that river catchment associations as well as water and irrigation

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* See Anonymous, 1993. Has your stream dried up?, <u>On Stream</u>, Issue No. 2, Summer 1993, p. 3.

** Note that GREEN originated in the USA. GREEN currently operates in the southern African context, in terms of a consortium of related projects known as SWAPCON (Schools Water Action Projects Consortium).

*** Cooper, K., 1996. Personal communication, Wildlife Society of Southern Africa, Durban. For a further discussion of integrated catchment management, see Division of Water, Environment and Forestry Technology of the CSIR and Walmsley Environmental Consultants, 1996. The philosophy and practice of integrated catchment management: implications for water resource management in South Africa, WRC Report No. TT 81/96, Water Research Commission and the Department of Water Affairs and Forestry, Pretoria, 140 p.

boards (discussed later) have a vital role to play - along with land owners - in integrated catchment planning and management.

10.16 Dams in Natal/KwaZulu

Data on 46 important dams in Natal/KwaZulu (as at 1986) are presented in Table J28. The following section examines aspects of dam safety. The environmental impacts of dams and associated works are then discussed.

10.16.1 Classification of dams for safety purposes*

Dams may be defined as being at risk on the basis of floods and earthquakes; subsidence of the dam or the foundation; seepages or leaks, or defects in the dam wall including deterioration of the concrete of the wall. Risk can also be due to sinkholes in the dam wall or dam basin; the movement of material masses near the dam basin perimeter; damage to slope protection; the unserviceability of spillways and outlet works (which may prevent rapid drainage of the dam), and incidents of sabotage or vandalism. Any one or more of the above conditions which poses a threat to the safety of the dam, or which implies a risk of loss of life or economic loss, will result in the dam being declared a dam with a safety risk. Every dam with a safety risk must be registered with the Department of Water Affairs and Forestry. The classification risk of such a dam may be revised from time to time. The owner of a dam with a safety risk, who proposes to alter or enlarge the dam, must obtain prior approval from the Department. An owner intending to build a new dam of a given size is likewise required to seek prior approval (and a classification rating) from the Department.

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* Discussion based on Anonymous, 1986. Republic of South Africa Government Gazette No. 10366 of the 25th July 1986, Government Printer, Pretoria, 28 p. (Government Regulation Notice GN R1560/86, issued in terms of Section 9C(6) of the Water Act No. 54 of 1956).

Table J28: Some relevant data on selected dams in Natal/KwaZulu.

Locality number	Name of dam (and nearest town)	Catchment area (km^2)	Evaporation area at full supply level (ha)	Reduced level of full supply level (m)	Gauge plate reading at full supply level (m)	Capacity at full supply level ($10^6 m^3$)	Sediment accumulation as a percentage of full capacity
U200/01	Albert Falls (New Hanover)	1 644	2 352	655,86	665,80	289,166	0,10
V300/03	Amcor (Newcastle)	488	41	1 179,10	6,00	0,726	0
V300/04	Chelmsford (Newcastle)	830	3 440	1 245,11	18,59	198,438	1,68
V100/09	Clifford Chambers (Bergville)	186	-	1 225,50	-	-	0
W300/04	Coronation (Ngobeni)	-	-	-	-	-	0
V200/02	Craigieburn (Greytown)	152	207	1 304,52	21,30	23,446	0,46
T300/16	Crystal Springs (Kokstad)	-	-	-	-	1,306	0
V100/04	Driel (Bergville)	1 656	305,1	1 134,00	17,40	10,387	32,25
U400/02	Ekamanzi (New Hanover)	62	3	-	5,00	0,050	0
V200/11	Eshowe (Eshowe)	1 430	30,1	493,75	5,75	0,910	0
T500/01	Gilbert Eyles (Port Shepstone)	427	29,5	565,40	9,14	0,955	33,50

Table J28: Some relevant data on selected dams in Natal/KwaZulu (continued).

Locality number	Name of dam (and nearest town)	Catchment area (km^2)	Evaporation area at full supply level (ha)	Reduced level of full supply level (m)	Gauge plate reading at full supply level (m)	Capacity at full supply level ($10^6 m^3$)	Sediment accumulation as a percentage of full capacity
W120/01	Goedertrouw (Eshowe)	1 273	1 197	214,00	68,94	315,420	0,77
W210/01	Grootgewaagd (Vryheid)	16	30	1 356,40	11,0	1,136	0
V300/09	Hattingspruit (Dundee)	56	55	1 298,40	-	1,885	0
U300/01	Hazelmere (Verulam)	377	224	85,98	24,94	22,914	4,29
U200/09	Henley (Pietermaritzburg)	238	65,8	931,15	-	5,512	0
W330/05	Hlobane (Hlobane)	-	-	-	-	-	0
W300/03	Hluhluwe (Hluhluwe)	734	364,2	80,74	26,71	28,774	8,04
V300/10	Incandu (Newcastle)	290	16	1 223,00	-	0,345	0
V100/08	Jagersrust (Bergville)	-	10,4	1 212,69	4,55	0,476	0
V100/20	Khombe (Bergville)	52	-	1 223,26	-	-	0
V100/18	Kilburn (Bergville)	-	194,7	1 255,94	55,98	35,666	0,84

Table J28: Some relevant data on selected dams in Natal/KwaZulu (continued).

Locality number	Name of dam (and nearest town)	Catchment area (km^2)	Evaporation area at full supply level (ha)	Reduced level of full supply level (m)	Gauge plate reading at full supply level (m)	Capacity at full supply level ($10^6 m^3$)	Sediment accumulation as a percentage of full capacity
W210/12	Klipfontein (Vryheid)	-	298,8	1 090,00	17,82	18,970	0,12
U400/03	Merthley (Greytown)	-	74	-	-	1,138	0
V300/13	Mfushane (Dannhauser)	-	-	-	-	-	0
U200/03	Midmar (Howick)	928	1 564	1 043,90	22,22	177,114	0,13
T300/04	Mountain (Matatiele)	12	6	-	-	0,984	0
U200/10	Nagle (Pietermaritzburg)	2 535	154,2	403,86	24,15	23,200	0
U500/01	Nonoti (Mandini)	-	-	-	-	0,261	0
U700/05	Nungwane (Amanzimtoti)	58	-	362,71	-	-	0
W440/01	Pongolapoort (Mkuze)	7 831	13 273	137,16	67,97	2 500,600	-
V100/10	Putterill (Witsieshoek)	68	-	1 227,70	-	-	0

Table J28: Some relevant data on selected dams in Natal/KwaZulu (continued).

Locality number	Name of dam (and nearest town)	Catchment area (km^2)	Evaporation area at full supply level (ha)	Reduced level of full supply level (m)	Gauge plate reading at full supply level (m)	Capacity at full supply level ($10^6 m^3$)	Sediment accumulation as a percentage of full capacity
U600/03	Shongweni (Vernon Hooper Dam) (Durban)	803	122	301,10	-	12,061	0
V100/01	Spioenkop (Ladysmith)	2 400	1 538	1 070,48	37,12	279,627	2,23
U600/01	Sterkspruit (Hammarsdale)	47	10	558,7	-	0,355	0
U300/03	Syphon (Ndwedwe)	65	16	-	4,00	0,360	0
U300/11	Tom Worthington (Dundee)	-	-	-	-	1,890	0
U700/08	Umgababa (Illovo)	30,6	31,1	30,48	9,14	1,280	0
U800/07	Umzimaai (Umzinto)	17	-	102,90	14,00	0,261	0
W120/17	Van Niekerk Broer (Eshowe)	-	-	-	-	1,788	0
U300/12	Verdruk (Dundee)	-	-	-	-	0,809	0
V700/01	Wagendrift (Estcourt)	744	508,1	1 179,58	30,46	58,367	2,73

Table J28: Some relevant data on selected dams in Natal/KwaZulu (continued).

Locality number	Name of dam (and nearest town)	Catchment area (km^2)	Evaporation area at full supply level (ha)	Reduced level of full supply level (m)	Gauge plate reading at full supply level (m)	Capacity at full supply level ($10^6 m^3$)	Sediment accumulation as a percentage of full capacity
V600/01	Waterval [?]	-	-	-	-	-	0
U300/04	Wewe (Ndwedwe)	60	66	39,60	8,00	2,313	0
V100/16	Windsor (Ladysmith)	764	109	1 037,10	8,00	4,618	0
V100/02	Woodstock (Bergville)	1 149	2 912	1 175,56	40,00	381,000	0

Source: After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

See also: Olivier, H., 1977. Great Dams in Southern Africa, Purnell, Cape Town, 232 p.

Note: (i) Flow gauging station numbers, the river on which the dam is situated and location co-ordinates for certain of the dams are given in Table J24 (see earlier in the chapter).

(ii) The co-ordinates and rivers of the other 24 dams are provided below:

Dam	River	Co-ordinates	
Clifford Chambers	Tugela/Vaal	28°39'S	29°03'E
Coronation	Rietspruit	27°42'S	31°04'E
Crystal Springs	Mzintlava	31°31'S	29°24'E
Ekamanzi	Ekamanzi	29°16'S	30°38'E
Grootgewaagd	Magot	27°43'S	30°48'E
Hattingspruit	Hattingspruit	28°05'S	30°09'E
Hlobane	Rietspruit	27°43'S	31°02'E
Incandu	Incandu	27°47'S	29°53'E
Jagersrust	Tugela	28°36'S	29°07'E
Khombe	Khombe	28°42'S	29°05'E
Merthley	Keizers	29°03'S	30°32'E
Mfushane	-	28°02'S	30°01'E
Mountain	Keneka River tributary	30°22'S	28°48'E
Nonoti	Nonoti	29°16'S	31°21'E
Putterill	Putterillspruit	28°38'S	29°02'E
Sterkspruit	Sterkspruit	29°48'S	30°40'E
Syphon	Wewe	29°32'S	31°07'E
Tom Worthington	Ngabiya	28°05'S	30°09'E
Umzimaai	Mzimayi	30°17'S	30°43'E
Van Niekerk Broer	Gola	-	-
Verdruk	Ngobiya River tributary	28°05'S	30°09'E
Waterval	Sundays	-	-
Wewe	Wewe	29°32'S	31°08'E
Windsor	Klip	28°30'S	29°44'E

(iii) The Department of Water Affairs and Forestry, Durban, has data on numerous other dams in Natal/KwaZulu. Such data are required in terms of dam safety legislation (discussed below).

(iv) Statistics not always coinciding with the above data can be found in Anonymous, 1990. List of hydrological gauging stations July 1990, VOL 2, Part 1: gauging stations in stored/standing water, 177 p., and Part 2: meteorological stations, 153 p., Hydrological Information Publication No. 15, Directorate of Hydrology, Department of Water Affairs, Pretoria. Statistics (including sediment data) for a number of dams in Natal/KwaZulu can also be found in Noble, R.G. and Hemens, J., 1978. Inland water ecosystems in South Africa - a review of research needs, South African National Scientific Programmes Report No. 34, Cooperative Scientific Programmes, CSIR, Pretoria, 150 p. The (zero) sediment accumulation as a percentage of full capacity data in the above table, do not necessarily reflect the current situation in certain dams. Some updated sediment data are provided in Rooseboom, A., 1992. Sediment transport in rivers and reservoirs: a southern African perspective, WRC Report No. 297/1/92, Water Research Commission, Pretoria, various pages - see the chapter on water quality, elsewhere in this publication.

(v) The Department of Water Affairs and Forestry, Pretoria, undertook a series of hydrographic surveys on several important dams in Natal/KwaZulu. Data are presented on the storage capacity of each dam, as well as sediment statistics. An example is given below:

Anonymous, 1987. Henley Dam capacity determination, Hydrographic Survey, Directorate: Survey Services, Department of Water Affairs, Pretoria, 20 p. + app.

(vi) Diagrams and maps showing existing and planned dams (as envisaged in 1978) in Natal/KwaZulu are presented in Thorrington-Smith, Rosenberg and McCrystal, 1978. Towards a plan for KwaZulu: a preliminary development plan, VOL 1, The written report, 341 p., and VOL 2, Atlas of maps and illustrations, various pages, KwaZulu Government, Ulundi. Similar information can be found in Ninham Shand and Partners, 1971. Water resources of the Natal South Coast, Natal Town and Regional Planning Commission Report, VOL 18A, 31 p. + app., and VOL 18B, Appendices, various pages, Pietermaritzburg; as well as in Chew, J.A. and Bowen, 1965. The water resources of the Illovo River: a preliminary survey of the Illovo River and its water storage possibilities, Natal Town and Regional Planning Commission Report, VOL 12, Pietermaritzburg, 37 p. + app. See also Chew, J.A. and Bowen, 1971. The water resources of the coastal areas of northern Natal and Zululand, Natal Town and Regional Planning Commission Report, VOL 17, Pietermaritzburg, 18 p. + app., plus James, W., 1973. Storage of water on the Zululand coastal plains: a brief study of the feasibility of conserving runoff from the lower-lying parts of most Natal catchments, and of distributing the water from a storage area in Zululand to coastal demand centres, Natal Town and Regional Planning Commission Report, VOL 22, Pietermaritzburg, 57 p.

(vii) Some data such as capacity and the irrigation potential of irrigation dams on farms in Natal, for which a subsidy was applied for, are available from the Department of Agriculture, Private Bag X9059, Pietermaritzburg, 3200. Data on dams and reservoirs in KwaZulu built by or on behalf of the KwaZulu Department of Agriculture and Forestry, or the KwaZulu Department of Works, are available from the respective departments at Private Bag X05, Ulundi, 3838, and Private Bag X03, Ulundi, 3838.

(viii) Readers should note that the names of one canal and 11 dams in South Africa have been changed. The relevant information is as follows:

Old name of dam/canal	New name of dam/canal
Braam Raubenheimer Dam (eastern Transvaal)	Kwena Dam
Charlie Malan Dam (eastern Cape)	Impofu Dam
Fanie Botha Dam (northern Transvaal)	Tzaneen Dam
Hans Strijdom Dam (northern Transvaal)	Mokolo Dam
H.F. Verwoerd Dam (Orange Free State)	Gariep Dam
Hudson Ntsanwisi Dam (eastern Transvaal)	Nsami Dam
Jan Wassenaar Dam (northern Transvaal)	Klaserie Dam
Lake Mentz (eastern Transvaal)	Darlington Dam
Nokmokgomo Matlala Dam (eastern Transvaal)	Arabie Dam
Paul Sauer Dam (eastern Transvaal)	Kouga Dam
P.K. Le Roux Dam (Orange Free State)	Vanderkloof Dam
Sarel Hayward canal (Orange Free State)	Orange-Riet canal

All dams with a wall height in excess of 5 m and a capacity of more than 50 000 m^3, are automatically considered to be dams with a safety risk. These dams must be classified on the basis of size and hazard potential, in order to determine the level of safety control required in terms of Government Regulation Notice GN R1560/86. The size classification of larger dams with a safety risk (dependent on wall height) is shown in Table J29.

Table J29: Size classification of dams with a safety risk.

Size class	Maximum wall height (m)
Small	More than 5 m but less than 12 m
Medium	Equal to or more than 12 m but less than 30 m
Large	Equal to or more than 30 m

<u>Source</u>: After Anonymous, 1986. <u>Republic of South Africa Government Gazette No. 10366 of the 25th July 1986</u>, Government Printer, Pretoria, 28 p. (Government Regulation Notice GN R1560/86).

The classification of dams (with a safety risk) by hazard potential is outlined in Table J30. The hazard potential rating for a particular dam is set at the highest level as determined by the potential loss of life <u>and</u> potential economic loss. Classification is based on the possible failure of the dam, without warning, on a normal sunny day. The final classification of dams with a safety risk (incorporating the relevant parameters), is provided in Table J31.

Table J30: Hazard potential classification of dams with a safety risk.

Hazard potential rating	Potential loss of life	Potential economic loss
Low	None	Minimal
Significant	Not more than 10 people	Significant
High	More than 10 people	Great

<u>Source</u>: After Anonymous, 1986. <u>Republic of South Africa Government Gazette No. 10366 of the 25th July 1986</u>, Government Printer, Pretoria, 28 p. (Government Regulation Notice GN R1560/86).

<u>Note</u>: For classification purposes, potential economic losses of less than R1 million and more than R10 million are considered "minimal" and "great" respectively (1986 prices).

Table J31: Category classification of dams with a safety risk.

Size class	Hazard potential rating		
	low	significant	high
Small	Category I	Category II	Category II
Medium	Category II	Category II	Category III
Large	Category III	Category III	Category III

Source: After Anonymous, 1986. Republic of South Africa Government Gazette No. 10366 of the 25th July 1986, Government Printer, Pretoria, 28 p. (Government Regulation Notice GN R1560/86).

All existing dams with a safety risk must be re-examined at intervals of not more than five years (following the initial safety inspection). Safety requirements for Category II and III dams are considerably more stringent than for Category I dams, and involve inspections by registered professional engineers meeting certain criteria. Plans for the construction or alteration of Category II and III dams must be submitted to the Department by these engineers, who must also supervise the work. Various other control measures apply to Category III dams. Owners of dams with a safety risk must apply appropriate operational procedures to prevent people or property downstream of the dam, from being flooded without warning by sudden changes in water levels. A subsidy is payable to farmers, irrigation boards and certain local authorities for costs incurred in complying with dam safety regulations. The subsidy only applies to dams built before the 25th of January 1987, or if construction began before this date. Permission to build a private dam in Natal must include an application to the Wetlands Advisory Committee, c/o the Department of Agriculture, Private Bag X9059, Pietermaritzburg, 3200, if there is a possibility of damage to, or flooding of wetlands.

For further information consult the following:

- Anonymous, 1986. Interim guidelines on safety in relation to floods: safety evaluation of dams, Report No. 1, South African [National] Committee on Large Dams, Pretoria, 36 p.

- Anonymous, 1990. Interim guidelines on dam break floods: safety evaluation of dams, Report No. 2, South African [National] Committee on Large Dams, Pretoria, no pagination.

- Anonymous, 1990. Interim guidelines on freeboard for dams: safety evaluation of dams, Report No. 3, South African National Committee on Large Dams, Pretoria, 23 p.

- Biersch, H.C., 1986. Responsibility of owner, engineer and regulatory authority, Symposium on Dam Safety, South African National Committee on Large Dams and the South African Institution of Civil Engineers, 23 - 25 September 1986, Pretoria, p. 2-1 to 2-8.

- Carmichael, G.P., 1982. Dam safety inspections in practice, Symposium on Dam Safety and Study Tour of Large Dams, South African National Committee on Large Dams, 14 - 15 October 1982, Golden Gate, 6 p.

- Pells, H.N.F., 1986. Dealing with emergency conditions at dams, Symposium on Dam Safety, South African National Committee on Large Dams and the South African Institution of Civil Engineers, 23 - 25 September 1986, Pretoria, p. 21-1 to 21-12.

- Van Schalkwyk, A., Jordaan, J.M. and Dooge, N., 1995. Die erodeerbaarheid van verskillende rotsformasies onder variërende vloeitoestande, WRC Report No. 302/1/95, Water Research Commission, Pretoria, 107 p. + app.

<u>For further information contact:</u>

- The Dam Safety Officer, Department of Water Affairs and Forestry, P O Box 1018, Durban, 4000, or Private Bag X313, Pretoria, 0001.

10.16.2 Environmental impacts of dams and other works*

The Department of Water Affairs and Forestry insists on an Environmental Impact Assessment (EIA) of all major water projects undertaken by, or on behalf of the Department. Public disclosure of all major projects is required in terms of Section 58 of the Water Act No. 54 of 1956. Accordingly, a report on the proposed works must be tabled as a Parliamentary White Paper (see Chapter 2). Recommendations that arise from EIAs are outlined in the White Papers and are implemented during the design, construction, operation (and decommissioning) phases of a project. Environmental Impact Assessments may be undertaken by staff of the Department, or via an environmental committee drawn from a wide range of expertise in both the private and public sectors.

In Natal/KwaZulu, the Drakensberg Pumped Storage Scheme** and the Mfolozi River Basin Project for example, have both been subject to EIAs. Environmental issues considered in EIAs vary from project to project, where both beneficial and negative environmental effects are examined. Short term landscape planning and site restoration measures***, plus longer term implications (such as the release of water to maintain riverine or estuarine ecology), are important factors in the analysis of dam construction projects****. The environmental effects usually studied may be grouped according to their impact on man (socio-economic parameters), as well as geophysical aspects, water, climate, flora and fauna. The impacts that various engineering activities (associated with major water projects), have on the environment are shown in simplified matrix form

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* Discussion based on Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages. See also, Roberts, C.P.R., 1981. Environmental considerations of water projects, In: Hattingh, W.H.J. (ed), Water Year + 10 and Then?, Technical Report No. TR 114, Department of Water Affairs, Forestry and Environmental Conservation, Pretoria, p. 106 - 123., as well as the section on The conservation status of South African rivers in the chapter on water quality.

** See Roberts, C.P.R. and Erasmus, J.J., 1982. Environmental considerations of the Drakensberg Pumped Storage Scheme, Civil Engineer in South Africa, VOL 24(8), p. 361 - 373, 455.

*** See Anonymous, 1986. Completion report: landscape rehabilitation of the Drakensberg Pumped Storage Scheme, Report No. V/V100/18/E005, Department of Water Affairs, Pretoria, 35 p. + app., as well as Prior, E.E., 1984. Towards successful grassing of civil engineering projects, Civil Engineer in South Africa, VOL 26(10), p. 491 - 493. (Brief overview details (including environmental aspects), of several of the larger dams in South Africa, can be found in a series of pamphlets available from the Department of Water Affairs and Forestry. Example: Inanda Dam - Mgeni River Government Water Scheme).

**** See Anonymous, 1987. Towards establishing the potential environmental impact of the proposed KwaMshaya Dam, Environmental Advisory Services, Durban, 22 p. + app.

in Table J32, where the main groups of environmental effects resulting from project activities are listed (as per the International Commission on Large Dams - ICOLD). Also listed are the specific parameters which could be influenced, and certain corrective measures required to reduce any adverse effects. It should be noted that not all elements of the matrix are scored and that only the major positive or negative impacts are reflected in the matrix. Primary environmental impacts can also result in secondary interactions with other environmental factors, with highly complex situations arising. Table J33 outlines some environmental effects of water projects according to ICOLD.

The matrix approach of the International Commission on Large Dams has been found to be too subjective, although the matrix provides a good checklist (Anonymous, 1986). A more descriptive approach readily understood by a variety of disciplines is generally preferred by the Department of Water Affairs and Forestry. Overlay techniques which superimpose mapped environmental factors are also used. Major environmental constraints on future water resources development in South Africa include the time consuming process of undertaking EIAs; the incorporation of relevant findings in the project; limitations on the development potential of sites suitable for major impoundments as a result of environmental considerations, and the quantity and quality of water necessary for environmental management*.

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* It is interesting to note that the construction of dams in South Africa is no longer automatically viewed (by the Department of Water Affairs and Forestry), as "the solution" to a particular water supply problem. Attention is now being given, for example, to the clearing of dense thickets of exotic (alien) vegetation which have invaded important catchments and riparian zones. The reduction in area of exotic species (which generally consume more water than indigenous plants), results in a nett increase in runoff, and hence a greater availability of water for downstream requirements. It should be borne in mind however, that additional commercial afforestation (<u>where permitted</u>), may negate the positive effects of alien vegetation removal. The felling of alien species is an integral component of the RDP Water Conservation Programme, which in turn is part of the Reconstruction and Development Programme.

Table J32: A simplified form of the environmental matrix used by the International Commission on Large Dams, with respect to project activities.

A = Employment, B = Tourism, C = Trade, D = Industry; E = Erosion, F = Sedimentation, G = Flooding, H = Drainage; I = Biology, J = Salinity, K = Evaporation, L = Runoff; M = New mesoclimate; N = Afforestation, O = Phytoplankton, P = Rare species; Q = Economic fish species, R = Rare species, S = Zooplankton, T = Microorganisms		Social and economic impacts				Geophysical impacts				Impacts on water				Climate	Terrestrial and aquatic flora			Terrestrial and aquatic fauna			
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Water uses	Irrigation			+	+	•			•		•										
	Energy	+								•		•									
	Drinking water	+										•	•	•	+						
Physical factors	Presence of dam		+					+	•	+	+	•					•	•	+	+	
	Diversion of water							+	+		•		•								
	Construction site	+				•	•								•						
Areas affected	Submerged areas					•			•				+		•		•		•		
	Reservoir fluctuation zone													+						•	•
	Groundwater										•				•						
Corrective action	Fish restocking		+														+	+		+	
	Erosion control					+											+				
	Water level control		+					+	+								+		+		

<u>Source</u>: After Anonymous, 1986. <u>Management of the Water Resources of the Republic of South Africa</u>, Department of Water Affairs, Pretoria, various pages.

Note: (i) Impacts: + beneficial; ● adverse. Other scoring factors: importance, probability of occurrence, term and duration.

(ii) The environmental impacts of dams will vary depending inter alia on the specific purpose for which the dam was constructed. The Qedusizi Dam (presently under construction) for example, is to be used for flood control. The dam, on the Klip River, will be kept as empty as possible in order to alleviate floods and accordingly, to prevent damage to the town of Ladysmith.

Table J33: Actions and environmental effects of water projects (according to the environmental criteria of the International Commission on Large Dams).

Characteristics of actions	Environmental effects
1. **Water consumption:** Irrigation Ecology Energy and power Domestic use River control Industrial use Shipping Fire fighting Fishing Recreation	1. **Impact on man:** ● Economic impacts Industry and commerce Provision of employment Tourism Agriculture and stock farming Communications Local financing Land values ● Social impacts Social acceptance Recreation Local landmarks and character Appearance Domestic water supply Land purchases Depopulation of rural areas Protection against natural disasters Health
2. **Physical factors:** Presence of dam Dam structure River diversion Construction site Coffer dam Buildings Deforestation Stone quarries and borrow areas Shipping locks Channels and pipelines Water discharges Inflow and permanent diversions Conveyance routes	2. **Geophysical impacts:** Morphology Erosion Sediment in suspension Channel load New water-retaining lands Floods Gradient stability Stimulation of earthquakes Soil salinity Sedimentation and aggradation Reclamation and drainage Tidal changes

Table J33: Actions and environmental effects of water projects (according to the environmental criteria of the International Commission on Large Dams) (continued).

Characteristics of actions	Environmental effects
3. Areas affected: Storage reservoir Vicinity of reservoir Area between full supply and lowest drawdown levels River above reservoir River below reservoir Irrigation canals Groundwater Coastline	**3. Influence on water:** Biological Physical and chemical Salinity Turbidity and suspended solids Temperature Evaporation River flow Water losses Water level
4. Physical remedial action: Fish management Dependable river flow Tourism development Water level control Infrastructure Afforestation Erosion control Dredging Releases from storage Support dam Compensation storage Floating barrier Water catchment control Water treatment Improved industries Resettlement	**4. Climate:** New mesoclimate
5. Legal and administrative action: Rates and levies Revaluation of land Town and regional planning	**5. Influence on land and water flora:** • Land flora Forests Moorland and fallow land Grasslands Cultivated lands
	• Water flora Superior plants Active micro-flora Plant plankton Scarce/endangered plants

Table J33: **Actions and environmental effects of water projects (according to the environmental criteria of the International Commission on Large Dams) (continued).**

Characteristics of actions	Environmental effects
6. **Other:**	6. **Influence on land and water fauna:** • Land fauna Mammals Birds Insects Reptiles and amphibians
	• Water fauna Economic fish species Other fish species Zooplankton Invertebrates Microorganisms Scarce and endangered species

Source: After Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

See also: (i) Little, T., 1994. Economics and water management: booklet on the application of economic principles to water management, INR Monograph No. 12, Institute of Natural Resources, University of Natal, Pietermaritzburg, 24 p.

(ii) Mirrilees, R. and Forster, S., 1993. Environmental resource economics - managing South Africa's environmental resources: a possible new approach, Department of Environment Affairs, Pretoria, 32 p.

(iii) Stewart, T.J., Scott, L. and Iloni, K., 1993. Scenario based multicriteria policy planning for water management in South Africa, WRC Report No. 296/1/93, Water Research Commission, Pretoria, 59 p. + app.

Note: Reservoir-induced earth tremors or earthquakes (and associated landslides), may be problematic in certain parts of the world (due to pressure exerted by the great volume of water - detailed seismic risk assessments notwithstanding). Data on earth tremors and earthquakes in southern Africa can be found in annual reports published by the Department of Mineral and Energy Affairs (Geological Survey, now the Council for Geoscience), Private Bag X112, Pretoria, 0001. See for example: Graham, G., Brandt, M.B.C., Ford, M., Saunders, I. and Brink, L., 1995. Catalogue of earthquakes in southern Africa and surrounding oceans for 1991, Seismologic Series of the Geological Survey No. 26, Council for Geoscience, Pretoria, 22 p. Note that the first such report (with a slightly different title), was issued in 1969. The current title was assumed in 1974 (Report No. 6).

There is a growing South African literature concerning the impact of water and other infrastructure projects on the environment (see the bibliographic database). Reference is made, for example, to the ecological implications of inter-basin water transfers (Petitjean and Davies, 1988)*; the ecological effects of stream regulation by dams on the Palmiet River, western Cape (Byren and Davies, 1988)**; the ecological investigation of proposed dams in the Umfolozi Game Reserve (Porter, 1978)***, and the effects of works construction and water withdrawal from the Muzi Pan near St Lucia (Anonymous, 1988 - see Table J34 below). Such data are mostly site specific, where various checklists and matrices are presented, or the impacts discussed.

Table J34: Components of the environmental impact assessment matrix for the proposed Muzi Pan irrigation scheme.

Proposed actions which may cause environmental impacts
1. **Planning and pre-construction phase** Site meetings Site surveys Soil surveys
2. **Construction phase** Site clearing • Control structures Low level weir with control gate at Mkuze River "breakaway" point Inlet culverts to Muzi Pan Outlet pipe from Muzi Pan Training berm Control gate on channel to Tshanetshe Pan Control structure on outlet from Tshanetshe Pan Trenching Pipe laying Backfilling Borrowpit excavations Embankments

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* See Petitjean, M. and Davies, B., 1988. Ecological impacts of inter-basin water transfers - a case study, the Orange River project, The Naturalist, VOL 33(1), p. 27 - 33. See also, Petitjean, M.O.G. and Davies, B.R., 1988. A review of the ecological and environmental impacts of inter-basin water transfer schemes in southern Africa: synthesis (Part 1) and international bibliography (Part 2), Ecosystem Programmes Occasional Report Series No. 38, Foundation for Research Development, CSIR, Pretoria, 106 p.

** See Byren, B.A. and Davies, B.R., 1988. Some aspects of the ecological effects of stream regulation by dams on the Palmiet River, western Cape, The Naturalist, VOL 33(1), p. 37 - 44.

*** See Porter, R.N., 1978. Ecological investigation of dams in the Umfolozi Game Reserve, Public Works Construction and Transport, April 1978, p. 15 - 17, 21. (The above topics have also been addressed in the more formal journals - see the bibliographic database).

Table J34: Components of the environmental impact assessment matrix for the proposed Muzi Pan irrigation scheme (continued).

Proposed actions which may cause environmental impacts
3. Post-construction phase Channel switching Flood storage Flow regulation Installation of pumps Diversion channels Irrigation
Existing characteristics of the environment
1. Physical factors Flood flows Uncontrolled water levels Defined river course Good quality water
2. Ecological factors • Floodplain communities Herbaceous Woody • Pan communities Muzi Neshe Ovengweni Tshanetshe Swamp community (Mkuze) Lake St Lucia
3. Sociological factors Subsistence farming Communal grazing Fishing (subsistence) Pedestrian traffic • Commercial farming Dryland cultivation Irrigated cultivation

<u>Source</u>: After Anonymous, 1988. The potential environmental impact of the proposed Muzi irrigation scheme: a scoping study conducted on behalf of Campbell, Bernstein and Irving, Environmental Advisory Services, Durban, 41 p.

<u>See also</u>: Heeg, J. and Breen, C.M., 1982. Man and the Pongolo Floodplain, South African National Scientific Programmes Report No. 56, Cooperative Scientific Programmes, CSIR, Pretoria, 117 p. (See specifically, p. 78 - 80 and text).

<u>Note</u>: Impacts were defined as potentially unavoidable negative impacts, potentially avoidable negative impacts, and potentially positive impacts.

Attention has also been focused on the social aspects of dam construction - known as Social Impact Assessment (SIA) - where residents have to be moved. The Human Sciences Research Council has inter alia examined the social implications of dams proposed for the Pongola and Bivane rivers at the Jagtdrift* and Parys sites respectively. The Department of Geographical and Environmental Sciences at the University of Natal, Durban, has studied some implications of the Inanda Dam, while the Department of Environmental and Geographical Science at the University of Cape Town, has examined the impacts of several projects in the Cape and at St Lucia. An especially useful social impact checklist for the Mhlatuze Basin can be found in Anonymous (1991)**. The ecological and social effects of water releases and flooding from the Pongolapoort (Jozini) Dam have received considerable attention in the literature, while the ecological and social impact of proposed dune mining at St Lucia, is a current (and hotly debated) controversy (see the bibliographic database). The interested reader is advised to examine the literature and to integrate the various checklists and matrices for his/her own specific purposes. Relevant information was often too detailed and complex to reproduce here***.

For further information contact:

- CSIR Environmental Services, CSIR, P O Box 395, Pretoria, 0001.

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* See Du Plessis, I.D. (ed), 1989. Sosiale impakstudie: Jagtdriftdam, Centre for Environmental Psychology, Human Sciences Research Council, Pretoria, 115 p. + app. See also, Social Development Research Unit of the Human Sciences Research Council, Chunnett Fourie and Partners, Loxton Venn and Associates, and Van der Meer and Schoonbee Inc., 1993. Republic of South Africa/KaNgwane Permanent Water Commission: social impact assessment of the proposed Driekoppies Dam, Report No. PX 100/00/0193, Department of Water Affairs and Forestry, Pretoria, 153 p., plus Social Development Research Unit of the Human Sciences Research Council, 1993. Republic of South Africa/KaNgwane Permanent Water Commission: relocation action plan for the Driekoppies Dam, Report No. PX 100/00/0293, Department of Water Affairs and Forestry, Pretoria, 64 p. (SIAs generally consist of two phases. The first phase involves a pre-feasibility or feasibility study. The second phase concerns actual project implementation. Numerous issues such as the social impacts of construction operations and more importantly, the short and long term effects of the loss of the natural resource base as well as the familiar habitat are highly relevant).

** See Anonymous, 1991. Department of Water Affairs and Forestry, Mhlatuze Basin augmentation pre-feasibility study, VOL 6: Report on the Second IEM Mini-workshop, Report No. PW 120/00/0891, Watermeyer Legge Piesold and Uhlmann, Johannesburg, various pages.

*** A useful reference on Integrated Environmental Management (IEM), which includes river regulation, is the following: Preston, G.R., Robins, N. and Fuggle, R.F., 1992. Chapter 30. Integrated environmental management, In: Fuggle, R.F. and Rabie, M.A. (eds), Environmental Management in South Africa, Juta, Cape Town, p. 748 - 761. (See also Chapter 31. Environmental evaluation, p. 762 - 780).

- Department of Environmental and Geographical Science, University of Cape Town, Private Bag, Rondebosch, 7701.

- Department of Geographical and Environmental Sciences, University of Natal, Private Bag X10, Dalbridge, 4014.

- Department of Landscape Architecture, University of Pretoria, Pretoria, 0002.

- Department of Water Affairs and Forestry, Private Bag X313, Pretoria, 0001.

- EPPIC (Environmental Planning Professions Interdisciplinary Committee), P O Box 90142, Bertsham, 2013.

- Institute of Natural Resources, University of Natal, Private Bag X01, Scottsville, 3209.

- Research Group: Social Dynamics, Human Sciences Research Council, Private Bag X41, Pretoria, 0001.

- Research Institute for Reclamation Ecology, Potchefstroom University for Christian Higher Education, Private Bag X6001, Potchefstroom, 2520. (The Institute is involved with the rehabilitation of areas disturbed by construction or mining activities).

- South African Institution of Civil Engineers, P O Box 93495, Yeoville, 2143.

- South African National Committee on Large Dams (SANCOLD), P O Box 3404, Pretoria, 0001. (Publications of the International Commission on Large Dams can be obtained from SANCOLD).

10.17 Some legal aspects of water in South Africa*

The Water Act No. 54 of 1956 was originally aimed at controlling the use of water for agricultural requirements. According to Perkins (1993), the Act despite numerous amendments, remains largely agricultural with no legal provision for instance, of water for environmental needs (a serious omission)**. The Water Act however, is in the process of being extensively revised, with a much reduced emphasis on agricultural requirements. Industrial and domestic as well as environmental demands will receive preference. Besides the Water Act, over 30 other secondary and a few primary Acts also apply to water issues in South Africa (see the chapter on the laws of South Africa, elsewhere in this publication). Rationalization of the minor Acts in particular, is necessary. Water in South Africa (in terms of the Water Act) can be divided into two main categories, namely, public and private water.

10.17.1 Public and private water

Public water is water found in a public stream, which is defined as a natural stream flowing in a known and defined channel. The water can be commonly used for irrigation on two or more parcels of land which are riparian to the stream, where the parcels of land are the subject of separate original grants, or on one such piece of land, and also on State land which is riparian to the stream. If there is doubt as to whether the water is private or public, it is advisable to regard the water as public until proven otherwise by a Water

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* Discussion based on Perkins, J.C., 1993. The water user and the Water Act (Act 54 of 1956), South African Institution of Civil Engineers Lecture Course, 8 September 1993, University of the Witwatersrand, Johannesburg, 12 p. (Note: The above discussion is greatly simplified). See also, Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages, as well as O'Keeffe, J.H., Uys, M. and Bruton, M.N., 1992. Chapter 13. Freshwater systems, In: Fuggle, R.F. and Rabie, M.A. (eds), Environmental Management in South Africa, Juta, Cape Town, p. 277 - 315. (See in addition, Chapter 25. Rivers, p. 647 - 668). A useful overview reference is the following: Visser, F., 1989. Water: laws and management, Southern African Journal of Aquatic Sciences, VOL 15(2) (stated as VOL 16(2) in the paper), p. 159 - 181. A plain-text summary of the Water Act can be found in Anonymous, 1995. You and your water rights: South African law review - a call for public response, Department of Water Affairs and Forestry, Pretoria, 30 p.

** A useful legal perspective is the following: Uys, M., 1992. Statutory protection for the water requirements of natural ecosystems, Koedoe, VOL 35(1), p. 101 - 118. See also, Uys, M., 1996. A structural analysis of the water allocation mechanism of the Water Act 54 of 1956 in the light of the requirements of competing water user sectors, with special reference to the allocation of water rights for ecobiotic requirements and the historical development of the South African water law, VOL 1, WRC Report No. 406/1/96, and VOL 2, WRC Report No. 406/2/96, 793 p., Water Research Commission, Pretoria.

Court. Private water may be surface or groundwater. Private water includes all water which falls or originates in a natural way on a property, but which is not capable of common irrigation use. The owner has the sole use of the water, but may not cede or sell this right to any other person, or transfer the water across the boundaries of the property on which it arises, without a permit.

10.17.2 Riparian rights

In terms of Section 9(1) of the Water Act, each riparian owner is entitled to the reasonable use of his share of the "normal flow" of a public stream, to which his property is riparian. Normal flow in a public stream refers to the volume of public water actually and visibly flowing in the stream which, under a system of direct irrigation from the stream whether by furrow or another method, but without the aid of storage, can be beneficially used for the irrigation of land riparian to the stream. In essence, irrigable land can be defined as land suitable for irrigation which is riparian to a stream and is irrigable - with the static plus friction head required not exceeding 80 m - or is situated within 2 km of the river course, excepting where canalization can increase this command distance. Normal flow can only be determined by a Water Court in terms of Sections 34 and 35 of the Water Act. Each property bordering a river does not necessarily have a water right, for example, where the right has been excluded by a prior subdivision. Assuming no exclusion, owners of riparian properties have a preferential right at all times to utilize water from a public stream (or a tributary thereof), for domestic and stock watering purposes. Such a use takes precedence over all other uses.

Normal flow (as per the Department of Water Affairs and Forestry), generally refers to the volume of water which is available in a public stream for direct irrigation for 70% of the time (mean exceedance flow), during the four driest months of the year*. The area which can be irrigated by this flow, divided by the potentially irrigable area, is known as the Theoretical Abstraction Right (T.A.R.) which is expressed as a percentage, for example, 65% on the Tugela River.

"Surplus water" in a public stream by contrast, refers to public water flowing or found in the stream (other than normal flow), if any. Surplus water implies some form of storage. Where surplus water is stored in a public stream, the normal flow of downstream users must be allowed to pass without interruption.

In most instances, it is assumed that irrigators are aware of the limitations imposed by the Water Act. However, in irrigation districts (discussed later), irrigation boards assume some of the responsibilities of the Water Act. In Government water control areas (discussed below), the Minister of Water Affairs and Forestry determines, and then publishes the water rights of individual properties in the Republic of South Africa Government Gazette, with due regard to the fair share principle.

In areas outside formal Government water control areas the same fair share principle operates with respect to normal flow (as within control areas), except that water rights are not determined and published, unless the land owners voluntarily apply to the Water Court, or objections are lodged by aggrieved owners who believe that other land owners are exceeding their rightful share of water. The only control that the Department of Water Affairs and Forestry has over such abstractions, is in terms of Section 9B(1) of the Water

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* Frequency distribution curves of monthly flows can be found in Pitman, W.V., Middleton, B.J. and Midgley, D.C., 1981. Surface water resources of South Africa, VOL VI: drainage regions UVWX. The eastern escarpment Part 1 (Text), various pages, and Part 2 (Appendices), various pages, HRU Report No. 9/81, Hydrological Research Unit, University of the Witwatersrand, Johannesburg. The curves express monthly flows for various hydrological zones, as a percentage of mean annual runoff, thereby enabling an estimation of normal flow to be made. Proceed by measuring all the irrigable land of riparian owners up to the point where the normal flow is calculated. In the case of a stream contributing less than 15% to the normal flow of the main stream, normal flow is usually calculated at the confluence with the main stream, and the division of water for the smaller stream is done separately. The same is done for the main stream, subtracting the normal flow required for irrigation in streams contributing less than 15% of the normal flow of the main stream. The normal flow is then divided proportionally between all the riparian owners, bearing in mind the restrictions of the Pietersburg principle (described in Pitman, Middleton and Midgley (1981)), which states that none of the competing properties may compete with more than a share equal to the total normal flow at that point. A useful background publication on the distribution of agricultural water is the following: Barry, A.H. and Le Roux, M.J., 1967. Apportionment of water for agricultural purposes in South Africa, Technical Report No. TR 42, Department of Water Affairs, Pretoria, 5 p. (The publication contains the formula usually used to determine the water rights of each land owner).

Act. The Act requires that anyone abstracting water at a rate in excess of 110 ℓ s^{-1}, or impounding more than 250 000 m^3 of water, must obtain a permit from the Minister of Water Affairs and Forestry. These limitations are not absolute. Each riparian owner accordingly, is not automatically entitled to abstract up to 110 ℓ s^{-1}. The fair share principle is again applied, since most South African rivers would not have sufficient water for all irrigators claiming 110 ℓ s^{-1}.

The limits of 110 ℓ s^{-1} and a storage of 250 000 m^3 are applied (in terms of an amendment - Section 9B(1C) - to the Water Act), to suit local conditions. For example, in the Mgeni River catchment the limits are currently 25 ℓ s^{-1} for abstractions and 50 000 m^3 storage for dams, above which, permits are required from the Minister. The opposite may also hold and the limits have been raised in some catchments. The policy regarding surplus flow abstractions is "first come, first served", assuming that beneficial use of the water occurs. This principle is applied when considering applications in terms of Section 9B of the Act. The needs however, of other consumers, future water resources development, afforestation and the environment must all be assessed.

10.17.3 Use of water by local authorities

Local authorities owning riparian land may also abstract their share of the normal flow, and as much surplus water as they can beneficially use. In terms of Section 13(3) of the Water Act no local authority may construct, alter or enlarge any waterwork in which more than 125 000 m^3 of public water is stored, or by means of which more than 5 000 m^3 of public water per day could be abstracted or diverted, without a permit. Following the granting of a permit, the local authority must apply to the Water Court unless exempted in terms of Section 11 of the Act. In Government water control areas permits for local authorities are usually issued by the Minister of Water Affairs and Forestry, in terms of Section 56(3) of the Water Act. In addition to the above, a permit is required by virtue of Section 12A of the Act for the erection, enlargement or alteration of the process of any water care work*.

* A water care work refers to a work used for the purification or treatment of water for human consumption or food processing, or for the purification, treatment or disposal of effluent or sewage.

10.17.4 Use of water by industrial undertakings

Any industrial undertaking (as defined) using more than 150 m^3 of water per day (both public and private water as well as sea water), must apply for a permit in terms of Section 12(1) of the Water Act. Important considerations are the prevention of pollution (including the purification/treatment of effluent and the correct operation of waste disposal sites), as well as the careful use of water. The industrial undertaking also requires permission from the Water Court in terms of Section 11(1) of the Water Act for water abstraction, unless exempted. Further details relating to water quality are provided in the chapter on water quality.

10.17.5 Water restrictions

The Minister of Water Affairs and Forestry (by virtue of Section 9A of the Water Act), may publish a notice in the Republic of South Africa Government Gazette controlling, regulating, limiting or prohibiting the impoundment, storage, abstraction, supply or use of water in any area with a water shortage, or where a water shortage is likely to occur.

10.17.6 Water research levy

The Water Research Commission was established in terms of the Water Research Act No. 34 of 1971, specifically to fund and undertake research into water and related issues. The Commission is financed in terms of Section 11 of the Act by a levy of R1,55 ha^{-1} in respect of each hectare of land scheduled by the Department of Water Affairs and Forestry, or supplied with water from any Government water scheme, irrigation board or other statutory body. A levy of 1,43 c m^{-3} on metered water is applicable to domestic, urban and industrial consumers supplied by the Department of Water Affairs and Forestry; as well as by water boards, irrigation boards, Joint Services Boards, or any other local authority of a given size. The levy is revised annually. The data presented here refer to 1993.

10.18 Some water control systems in Natal/KwaZulu*

Various categories of Government water control systems are described below. Mountain catchment areas (as opposed to catchment control areas), are examined in the chapter on catchments. Water boards in Natal/KwaZulu are then considered. A brief discussion of irrigation districts and boards in Natal concludes the present section.

10.18.1 Government water control areas

Government water control areas are declared by the Minister of Water Affairs and Forestry in order to protect public water sources against over-exploitation, and to ensure that all water users within the control areas receive their rightful share of the available water. Areas of existing irrigated land and of potentially irrigable land must first be determined. The Minister (and not the Water Court), then apportions water through water rights and also regulates the abstraction and utilization of water in the control areas (in terms of Section 52 of the Water Act No. 54 of 1956). Aggrieved persons or agencies may apply to the Water Court if concensus cannot be reached on water rights, or the volume of water granted to a particular riparian owner. If an owner is found to be irrigating in excess of his right, that owner will have to reduce consumption or create storage, thereby irrigating the excess area with the surplus water. If surplus water is available (without storage), the owner may be given temporary permission to irrigate (in terms of Section 56(3) of the Water Act). There are three main types of Government water control areas, namely, river control areas, catchment control areas and subterranean water control areas**.

River control areas are established primarily to control water allocations to riparian owners downstream of Government dams, and to regulate the abstraction of water. Catchment control areas are demarcated to control the abstraction of water within the catchments of

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* Discussion after the Department of Water Affairs and Forestry, Durban, 1993.

** Two other Government water control areas concern firstly, drainage control areas, which are areas with a high water table requiring special drainage measures (none in Natal/KwaZulu), and secondly, dam basin control areas. The purpose of dam basin control areas is to reserve the storage basins of future (Government) dam sites, in order to prevent development or interference with the proposed (or envisaged) waterworks. There are no dam basin control areas in Natal/KwaZulu. It should be noted that in terms of Section 68(1) of the Act, the Minister may appoint an advisory committee for any Government waterwork, Government water control area, catchment control area, subterranean water control area and drainage control area, or any other catchment area/s.

Government dams, and also for water conservation purposes. Subterranean water control areas are established in order to manage the abstraction and development of subterranean water and of groundwater compartments, in the common interest. River control areas in Natal/KwaZulu include the Mhlatuze; Hluhluwe; Tugela; Pongola/Pongolapoort; Mgeni; Bushmans; Mnyamvubu; Mdloti; White Mfolozi; Ngagane; Assegaai; Buffalo, and Slang rivers. The only catchment control area in Natal/KwaZulu is the Craigieburn Dam. There are no subterranean water control areas in the province.

10.18.2 Government water schemes

Government water schemes are waterworks such as dams, canals, pipelines, tunnels, pumping stations, purification works and related works, constructed separately or in combination at State expense (in the general public interest) for the bulk supply of water. While the Department of Water Affairs and Forestry is legally responsible for many Government waterworks, the operation of the works is increasingly being transferred to water boards, the irrigation boards and other statutory bodies. A number of waterworks have also been privatised. The three broad categories of Government water schemes are firstly, Government irrigation schemes where the purpose is to supply water primarily (but not exclusively) for irrigation requirements (none in Natal/KwaZulu); secondly, Government water supply schemes to provide mainly raw water for urban and industrial needs (Table J35) and thirdly, Government water purification schemes (none in Natal/KwaZulu). The latter are for the supply of purified water in accordance with the relevant South African Bureau of Standards potable specifications (see the chapter on water quality).

10.18.3 Government-assisted water schemes

The Department of Water Affairs and Forestry administers subsidy and loan schemes for the construction of water supply and sewage purification works, by local authorities and statutory bodies (including waterworks constructed by irrigation boards). The Department also provides technical and other professional assistance where necessary.

Table J35: Government water supply schemes owned and administered by the Department of Water Affairs and Forestry or administered by Umgeni Water in Natal/KwaZulu, 1993.

Scheme	Details
Bushmans River (Wagendrift Dam)	Department of Water Affairs and Forestry
Hluhluwe River (Hluhluwe Dam)	Department of Water Affairs and Forestry
Mdloti River (Hazelmere Dam)	Operated by Umgeni Water on an agency basis
Mgeni River (Albert Falls Dam, Midmar Dam and Inanda Dam)	Operated by Umgeni Water on an agency basis
Mhlatuze River (Goedertrouw Dam)	Department of Water Affairs and Forestry
Mnyamvubu River (Craigieburn Dam)	Department of Water Affairs and Forestry
Ngagane River (Chelmsford Dam)	Department of Water Affairs and Forestry
Pongola River (Pongolapoort Dam)	Department of Water Affairs and Forestry
Slang River (Zaaihoek Dam)	Department of Water Affairs and Forestry
Tugela River (Spioenkop Dam)	Department of Water Affairs and Forestry
Tugela-Vaal River Project	(Second phase - Drakensberg Pumped Storage Scheme, Natal/KwaZulu and the Orange Free State) Department of Water Affairs and Forestry
Tugela-Vaal River Aqueduct	(Natal/KwaZulu and the Orange Free State) Department of Water Affairs and Forestry
White Mfolozi River (Klipfontein Dam)	Department of Water Affairs and Forestry

Source: After the Department of Water Affairs and Forestry, Durban, 1993.

Note:

(i) Umgeni Water owns the Nagle, Henley, Shongweni and Nungwane dams and the Mearns raw-water pump station on the Mooi River.

(ii) Besides the Tugela-Vaal Project, the only other permanent inter-basin (as opposed to inter-catchment) transfer scheme in Natal/KwaZulu, is the Mooi-Mgeni Scheme (also known as the Mooi River Emergency Water Supply Scheme). The latter project was initiated during the drought of 1983. Water is transferred from the Mooi River (a tributary of the Tugela River), to Midmar Dam via the Mpofana and Lions rivers (both tributaries of the Mgeni River). A major extension of the scheme involving construction of the Mearns Dam on the Mooi River, plus a 10,5 km tunnel, is planned for the very near future. An emergency inter-basin water transfer scheme (pending the later completion of a permanent system), is under construction at Middeldrift on the Tugela River. Water will be pumped 19 km into a tributary of the Mhlatuze River and then stored in the Goedertrouw Dam. An emergency transfer scheme drawing water from the Pongola River, with input into the Mhlatuze system is also under construction. Readers should examine the annual reports of the

Department of Water Affairs and Forestry/the two water boards for details of new schemes and amendments to existing schemes.

(iii) An inter-basin transfer refers to the mass transfer of water from one geographically distinct river basin to another. Inter-catchment transfer involves the transfer of water from one tributary river catchment to another for a given river - but not from one river basin to another (Petitjean and Davies, 1988)*.

10.18.4 River diversions

A permit is required from the Minister of Water Affairs and Forestry for the diversion of the natural course of a public stream (in terms of Section 20 of the Water Act). The number of permits being issued is increasing due to the coal mining industry, and the use of open cast and other high yielding mining methods. Several river diversions have been undertaken by the Department in the environs of Dundee. The diversions form part of a programme to rehabilitate old coal mine dumps in order to prevent or to reduce the pollution of certain rivers in the Dundee area.

10.18.5 Water boards

Water boards derive their authority in terms of Sections 107 - 138 and 178 of the Water Act. Water boards are autonomous statutory bodies involved in the supply of bulk water (both raw and treated) to local authorities, any Government department, the Natal Provincial Administration and Joint Services Boards, as well as private individuals. Water boards also undertake wastewater treatment and water purification. There are two water boards in Natal/KwaZulu, namely, Umgeni Water, P O Box 9, Pietermaritzburg, 3200, and Mhlatuze Water, P O Box 1264, Richards Bay, 3900. Besides the four dams owned by Umgeni Water (Table J35), the following waterworks are also the property of the organization: Ixopo; Howick; Mill Falls; D.V. Harris; H.D. Hill; Umlaas Road; Durban Heights; Hazelmere; Wiggins, and Amanzimtoti. Sewage works owned by Umgeni Water include Ixopo; Hammarsdale; Darvill; Mpumalanga; KwaMakhutha; Mpophomeni; KwaDabeka; Isipingo (Umlazi); KwaNdengezi, and J. Ponds (Umlazi). The initial supply

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* See Petitjean, M.O.G. and Davies, B.R., 1988. A review of the ecological and environmental impacts of inter-basin water transfer schemes in southern Africa: synthesis (Part 1) and international bibliography (Part 2), Ecosystem Programmes Occasional Report Series No. 38, Foundation for Research Development, CSIR, Pretoria, 106 p.

area of Umgeni Water was 2 176 km^2, and subsequently 7 092 km^2. This area was increased to approximately 24 000 km^2 by virtue of Proclamation Proc 101/94 dated the 21st of January 1994. The new area stretches from the Tugela River mouth inland, then down to the Lesotho border and along the Mzimkulu and Mkomazi rivers to the sea. Besides urban areas such as Pietermaritzburg, Durban, Wartburg, Howick and Hilton (in the previous supply area), additional urban areas served are Stanger; Kranskop; Greytown; Mooi River; Impendle; Himeville; Underberg; Richmond, and Ixopo. Also included are a few urban areas in KwaZulu, plus numerous rural districts*. The new area encompasses some 5 000 000 people. Consideration is being given to extending this area southwards to the Transkei border.

A recently commissioned project, namely, the South Coast Augmentation Scheme will supplement bulk water supplies for the industrial and residential areas south of Durban. The scheme will result in an additional 27 Mℓ day^{-1} of water for the area. The scheme is designed to prevent a recurrence of water restrictions, which were imposed during the 1993/94 drought, for all consumers supplied from the Nungwane Dam. Umgeni Water has also assumed responsibility for the supply of bulk water to certain consumers originally served by the Southern Natal Joint Services Board. The area concerned is the coastal belt from Amanzimtoti to Mtwalume. Umgeni Water will accordingly manage the Mtwalume, Umzinto and Craigieburn waterworks as well as the E.J. Smith and Umzinto dams, plus all associated river abstraction sites.

The supply area of Mhlatuze Water is 36 000 km^2. The area served, stretches from Kosi Bay along the Mozambique border, south along the Swaziland border (including the town of Pongola in the Transvaal), then parallel to the Pongola River, around Vryheid, proceeding in a southerly direction to the Tugela River, and down to the coast. Urban areas served by Mhlatuze Water include Richards Bay, Empangeni, Eshowe, Ulundi (KwaZulu), Vryheid, Mkuze, Hluhluwe, Mtunzini and Mandini. Large parts of rural KwaZulu are included in the supply area. Mhlatuze Water owns the Empangeni and Lake Nseze waterworks, with possible future ownership of the Hluhluwe, Mkuze and Mtubatuba waterworks. The organization does not own any dams or sewage works.

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* An ambitious programme, known as the Rural Areas Water and Sanitation Plan (RAWSP), was initiated by Umgeni Water in 1990 to provide reticulated water to black peri-urban and rural households in the Umgeni Water supply area. Some 400 000 people have already been supplied with purified water. The programme, which includes sanitation projects, is on-going.

10.18.6 Irrigation districts and boards in Natal*

An irrigation district with a statutory board may be proclaimed in terms of the Water Act No. 54 of 1956, in circumstances where three or more owners of land riparian to a public stream (or a tributary thereof), and who together own not less than 10% of the land irrigated or intended to be irrigated, request the Minister of Water Affairs and Forestry to declare such a district. If approved, an irrigation district is proclaimed by the State President (Table J36). The Minister of Water Affairs and Forestry may also recommend to the State President that any Government water control area or catchment area or part thereof, be proclaimed as an irrigation district. In the latter instance, matters affecting the water control or catchment area/s may be delegated by the Minister to the irrigation board. The two areas retain their specific purpose, notwithstanding inclusion in an irrigation district.

Irrigation boards are empowered to protect water resources; to levy rates and water charges in their areas of jurisdiction, and to undertake capital works relating to irrigation. They may also undertake other works in respect of Government water control areas or catchment areas (if instructed by the Minister). Irrigation boards are likewise empowered to control and supply water for domestic and industrial purposes, and to supply State departments, Provincial administrations and local authorities. It should be noted that irrigation boards cannot reduce the riparian rights of land owners and may only regulate water use. Irrigation boards can obtain loans from the Land and Agricultural Bank of South Africa in order to construct works. This only applies to economically viable schemes. A one-third State subsidy is payable for irrigation schemes with no maximum limit (funds permitting). Sections 71 - 106; 153 - 164, and 178 of the Water Act deal with irrigation boards. Data on the various irrigation boards in Natal are provided in Table J37.

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* Discussion based on Hall, C.G. and Burger, A.P., 1974. Hall on Water Rights in South Africa, Juta, Cape Town, 393 p., as well as Vos, W.J., 1978. Principles of South African Water Law, Juta, Cape Town, 263 p. See also, Perkins, J.C., 1993. The water user and the Water Act (Act 54 of 1956), South African Institution of Civil Engineers Lecture Course, 8 September 1993, University of the Witwatersrand, Johannesburg, 12 p.

Table J36: Irrigation districts in Natal, 1993.

Irrigation district	Original date of establishment
Bergville	27 January 1989
Dwars-Nkunzi	19 August 1988
Gluckstadt	4 February 1972
Heatonville	4 February 1972
Hlatikulu-Little Mooi	9 May 1986
Illovo	23 December 1983
Impala	10 April 1992
Injambili	28 June 1985
Ixopo	2 December 1983
Karkloof	19 September 1986
Lindequespruit	6 March 1987
Little Tugela	3 May 1985
Lower Umvoti	3 April 1987
Merrivale*	19 September 1986
Mfuli	13 September 1935
Middle Umgeni*	4 December 1987
Mkuze Falls	10 August 1928
Mnyamvubu	8 June 1984
Mooi River	30 May 1986
Mpolweni-Sterkspruit*	3 April 1987
Muden	11 March 1977
Mzalanyoni	2 September 1983
Mzintlava	24 February 1984
Ngwangwane	19 September 1986
Nkwalini	16 July 1926
Polela	30 May 1986
Pongola River	19 September 1986
Sterkspruit	28 December 1984
Sundays River	24 August 1984
Umlaas	1 April 1977
Umvoti	8 June 1984

Table J36: Irrigation districts in Natal, 1993 (continued).

Irrigation district	Original date of establishment
Umzimkulwana	15 December 1989
Umzimvubu*	20 November 1987
Upper Umgeni*	3 April 1987
Weenen	Unknown
Winterton	Unknown

Source: After the Department of Water Affairs and Forestry, Durban, 1993.

Note: The asterisk denotes an irrigation district without an irrigation board.

Table J37: Irrigation boards in Natal, 1993.

Irrigation board and date of first election	Magisterial district	Contact address	Scheduled area (ha)	River	Storage dam
Bergville (1/9/1989)	Bergville	c/o H. Hodgsen, P O Box 133, Bergville, 3350	No data available	Tugela	None
Dwars-Nkunzi (21/7/1989)	Klip River	c/o I. Riddell, Private Bag X70153, Wasbank, 2920	>280	Dwars and Nkunzi	Mielietuinhoek Dam
Gluckstadt (17/3/1972)	Vryheid	c/o A. Van der Merwe, P O Box 690, Vryheid, 3100	498	Bizankulu; Hloyane and White Umfolozi	Bevenson Dam
Heatonville (17/3/1972; 30/4/1992)	Empangeni and Lower Umfolozi	c/o Coopers and Lybrand, P O Box 4, Eshowe, 3815	5 215,5	Mhlatuze	Goedertrouw Dam
Hlatikulu-Little Mooi (9/1/1987)	Mooi River	c/o J. Church, P O Box 134, Mooi River, 3300	999,5	Hlatikulu and Little Mooi	None
Illovo (30/3/1984)	Richmond	c/o C. Grant, P O Box 271, Richmond, 3780	941,51	Illovo	Beaulieu Dam
Impala (15/5/1992)	Piet Retief and Ngotshe	c/o C. Du Plooy, Private Bag X0012, Pongola, 3170	6 944,30	Pongola	None
Injambili (9/8/1985)	Port Shepstone	c/o B. Hulley, P O Box 53, Umzumbe, 4225	302	Injambili	None
Ixopo (17/2/1984)	Ixopo	c/o B. Stone, P O Box 121, Ixopo, 3276	801	Ixopo	St Isadore Dam

Table J37: Irrigation boards in Natal, 1993 (continued).

Irrigation board and date of first election	Magisterial district	Contact address	Scheduled area (ha)	River	Storage dam
Karkloof (25/9/1992)	Lions River	c/o R. Stubbs, P O Box 658, Howick, 3290	1 505	Karkloof, Kusane and Yarrow	None
Lindequespruit (5/6/1987)	Bergville and Estcourt	c/o V. Wortmann, P O Box 15, Winterton, 3340	>800	Lindequespruit	None
Little Tugela (28/6/1985)	Winterton	c/o S. Van Zuydam, P O Box 22, Winterton, 3340	2 781	Little Tugela	None
Lower Umvoti (24/7/1987)	Lower Tugela	c/o N. Kallidas, Gledhow Mill, P O Box 55, Stanger, 4450	No data available	Umvoti	None
Mfuli (14/8/1978)	Lower Umfolozi	c/o L. Brown, P O Box 1009, Empangeni, 3880	992,5	Mfuli and Mhlatuze	Goedertrouw Dam
Mkuze Falls (31/10/1969)	Ngotshe	c/o G. Van Zyl, P O Box 431, Pongola, 3170	867,4	Mkuze	None
Mnyamvubu (13/7/1984)	Umvoti	c/o W. Thorby, Private Bag X5595, Greytown, 3250	No data available	Mnyamvubu	None
Mooi River (9/1/1987)	Mooi River	c/o S. Gawith, P O Box 134, Mooi River, 3300	2 522	Mooi	None
Muden (7/4/1977)	Weenen	c/o P. March, P O Box 53, Muden, 3251	520,6	Mooi	Craigieburn Dam

Table J37: Irrigation boards in Natal, 1993 (continued).

Irrigation board and date of first election	Magisterial district	Contact address	Scheduled area (ha)	River	Storage dam
Mzalanyoni (23/9/1983)	Ixopo	c/o H. Anderson, Fauncette, P O Eastwolds, 3241	201	Mzalanyoni	Lilydale Dam
Ngwangwane (27/2/1987)	Underberg	c/o G. Lockhart, P O Box 185, Underberg, 3257	615	Ngwangwane	None
Nkwalini (1/10/1957)	Eshowe	c/o Coopers and Lybrand, P O Box 4, Eshowe, 3815	6 231,43	Mhlatuze and Nkwaleni	Goedertrouw Dam
Polela (7/11/1986)	Underberg	c/o R. Snale, P O Box 28, Himeville, 3256	1 362	Polela	None
Pongola River (29/5/1987)	Piet Retief and Ngotshe	c/o A. Strydom, P O Box 617, Pongola, 3170	>2 000	Pongola	None
Sterkspruit (22/1/1985)	Estcourt	c/o C. Stockil, P O Box 22, Winterton, 3340	1 719	Sterkspruit	Bell Park Dam
Sundays River (17/9/1984)	Klip River	c/o I. Mitchell-Innes, P O Box 52, Elandslaagte, 2900	1 507,8	Sundays	Slangdraai Dam
Umlaas (9/8/1977)	Camperdown and Richmond	c/o J. De Ravel, P O Box 86, Umlaas Road, 3730	4 099,55	Umlaas	Thornlea Dam and Baynesfield Dam
Umvoti (13/7/1984)	Umvoti	c/o P. Kohne, P O Box 266, Greytown, 3250	No data available	Umvoti	None

Table J37: Irrigation boards in Natal, 1993 (continued).

Irrigation board and date of first election	Magisterial district	Contact address	Scheduled area (ha)	River	Storage dam
Umzimkulwana (12/4/1990)	Alfred	c/o P. Anderson, P O Box 342, Harding, 4680	436 (from dam) 50 (from river)	Umzimkulwana	Umzimkulwana Dam
Weenen (Unknown)	Estcourt	c/o L. Cunha, P O Box 14, Weenen, 3325	1 504,67	Bushmans	Wagendrift Dam
Winterton Settlement (Unknown)	Estcourt	c/o S. Van Zuydam, P O Box 22, Winterton, 3340	>1 224	Little Tugela	None

Source: After the Department of Water Affairs and Forestry, Durban, 1993.

Note:

(i) Irrigation boards (and districts) are not static entities. Boards are sometimes established and then later disbanded; possibly consolidated with other boards, or subsequently incorporated into adjacent boards. A typical example is Mfuli. The date of the first election indicated in the table therefore refers to the latest form of a given board. The names and addresses of contact persons likewise, change from time-to-time. In the event of difficulties the Department of Water Affairs and Forestry, Durban, should be approached for assistance. The Department maintains constantly updated records on the various districts and boards.

(ii) The following irrigation boards are in the process of being established: Horn River; Ivala; Krom River; Lions River; Lower Tugela; Makatini; Melmoth; Nkonzo River; Northern Zululand; Port Edward; Umsinduze, and Underberg. The Mzintlava Irrigation Board is being disbanded.

10.19 The provision of services in Natal/KwaZulu

10.19.1 Local authorities and services in Natal*

Local authorities in Natal as of August 1993 consisted of 37 boroughs, 29 town boards and 31 health committees, which were established in terms of the (Natal) Local Authorities Ordinance No. 25 of 1974 and previous legislation. Black local authorities consisted of 13 town committees and four local authority committees established by virtue of the Black Local Authorities Act No. 102 of 1982 (Table J38). Several towns on (former) South African Development Trust (SADT) (previously the South African Native Trust) land were established in terms of the (now repealed) (Native) subsequently, Black Administration Act No. 38 of 1927 and the (now repealed) (Native) subsequently, Development Trust and Land Act No. 18 of 1936. A number of hamlets were established on SADT land (and administered) in terms of the National States Constitution Act No. 21 of 1971 plus relevant Proclamations and Regulation Proclamations. These hamlets are controlled by the Natal Townships Board. Some of the hamlets were later transferred to KwaZulu (although still administered by the Board in the interim). Hamlets remaining in Natal are currently administered in terms of Proclamations and Government Notices issued under the Black Administration Act No. 38 of 1927.

The situation in Natal with regard to land and accordingly, local authorities and hence the provision of services is highly complex, and will change in the future. Historical background only, is provided to enable the reader to more fully understand the situation and to peruse the literature. Briefly, certain areas in Natal (and the rest of South Africa), known as "scheduled areas" (in terms of the since repealed (Natives') subsequently, Black Land Act No. 27 of 1913), were reserved for occupation by blacks under traditional land tenure. After 1913, blacks were not permitted to purchase land outside the scheduled

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* Discussion based on Ardington, E.M., 1989. Rural towns and basic needs, Rural Urban Studies Working Paper No. 20, Centre for Social and Development Studies, University of Natal, Durban, 91 p., and Botha, S., 1993. Personal communication, Community Services Branch, Natal Provincial Administration, Pietermaritzburg. Certain important changes in the laws are outlined in: Monitor Editorial Panel, 1992. 1991: a year of change, Monitor, No. 15, February 1992, p. 1 - 3. See also, Davenport, T.R.H., 1990. Land legislation determining the present racial allocation of land, Development Southern Africa, VOL 7 (Special issue), p. 431 - 440. A brief overview of some of the more important (historical) legislation dealing with land issues, is the following: Budlender, G. and Latsky, J., 1991. Chapter 6. Unravelling rights to land in rural race zones, In: De Klerk, M. (ed), A Harvest of Discontent: the Land Question in South Africa, Institute for a Democratic Alternative for South Africa, Cape Town, p. 115 - 137.

Table J38: Some urban areas in Natal, 1993.

Magisterial district	Urban area	Status
Alfred	Harding	Town Board
Amanzimtoti	Lovu	Development Area
Babanango	-	-
Bergville	Bergville	Borough
Camperdown	Assagay	Health Committee
	Botha's Hill	Health Committee
	Camperdown	Health Committee
	Cato Ridge	Health Committee
	Cliffdale	Regulated Area
	Craiglea	Development Area
	Drummond	Health Committee
	Hammarsdale	Development Area
	Harrison	Regulated Area
	Inchanga	Development Area
	Inchanga West	Development Area
	Manderston	Regulated Area
	Sterkspruit	Development Area
	Thornville	Regulated Area
	Umlaas Road	Regulated Area
Chatsworth	Shallcross	Development Area
	Welbedagt	Development Area
Dannhauser	Dannhauser	Town Board
	Mafusini	NPA Transit Camp
Dundee	Dundee	Borough
	Sibongile	Town Committee
	Talana	Health Committee
Durban	Amanzimtoti	Borough
	Chesterville	Ningizimu Town Committee
	Durban	Borough
	Isipingo	Borough
	Kingsburgh	Borough

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
Durban (continued)	Lamontville	Ningizimu Town Committee
	Lower Illovo	Health Committee
	Queensburgh	Borough
	Umbogintwini	Town Board
	Yellowwood Park	Health Committee
Eshowe	Eshowe	Borough
Estcourt	Cathkin Park	Regulated Area
	Colenso	Borough
	Driefontein	Development Area
	Estcourt	Borough
	Estcourt	NPA Compound
	Nkanyezi	Town Committee
	Spioenkop	Regulated Area
	Wagendrift	Regulated Area
	Winterton	Health Committee
	Winterton	NPA Emergency Camp
Glencoe	Glencoe	Borough
	Hattingspruit	Health Committee
	Sithembile	Town Committee
	Wasbank	Development Area
Hlabisa	Hluhluwe	Development Area
	Mtubatuba	Health Committee
	St Lucia	Town Board
Impendle	Boston	Regulated Area
	Impendle	Health Committee
Inanda	Blackburn	Regulated Area
	Buffels Draai	Regulated Area
	Canelands	Health Committee
	Duff's Road	Development Area
	Hambanathi	Town Committee
	Hazelmere	Regulated Area

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
Inanda (continued)	Mount Moreland	Development Area
	Ottawa	Development Area
	Redcliffe	Development Area
	Riet Rivier	Development Area
	Tongaat	Town Board
	Umdhloti Beach	Town Board
	Umhlanga Rocks	Borough
	Verulam	Borough
	Waterloo	Development Area
Ixopo	Creighton	Health Committee
	Ixopo	Health Committee
	Stuartsville	Regulated Area
Klip River	Ladysmith	Borough
	Rietkuil	Regulated Area
	Steadville	Town Committee
Kranskop	Kranskop	Health Committee
Lions River	Fort Nottingham	Development Area
	Howick	Borough
	KwaMevana	Local Authority Committee
	Lidgetton West	Development Area
	Midmar	Regulated Area
Lower Tugela	Ballitoville	Borough
	Blythedale Beach	Health Committee
	Darnall	Health Committee
	Etete	Black Development Area
	Port Zimbali	Development Area
	Prince's Grant	Development Area
	Shakaskraal	Health Committee
	Shakaville	Local Authority Committee
	Stanger	Borough
	Tinley Manor Beach	Development Area

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
Lower Tugela (continued)	Tugela	Development Area
	Umhlali Beach	Town Board
	Zinkwazi Beach	Health Committee
Lower Umfolozi	Empangeni	Borough
	KwaMbonambi	Development Area
	Richards Bay	Borough
Mooi River	Bruntville	Town Committee
	Mooi River	Borough
	Mount Dragon	Regulated Area
	Sierra Ranch	Regulated Area
Mount Currie	Bhongweni	Town Committee
	Cedarville	Town Board
	Itsokolele	Town Committee
	Kokstad	Borough
	Matatiele	Borough
	Mzingisi	Local Authority Committee
Mtonjaneni	Melmoth	Town Board
	Thubalethu	Black Development Area
Mtunzini	Gingindlovu	Town Board
	Mandini	Town Board
	Mangete	Regulated Area
	Mtunzini	Town Board
	Tugela Mouth	Development Area
	Umlalazi	Regulated Area
Newcastle	Charlestown	Development Area
	Chelmsford	Regulated Area
	Drystream	Regulated Area
	Hlobane	Black Development Area
	Newcastle	Borough

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
New Hanover	Cool Air	Development Area
	Cramond	Regulated Area
	Dalton	Health Committee
	Harburg	Regulated Area
	Mpolweni	Health Committee
	New Hanover	Health Committee
	Trust Feed	Black Development Area
	Wartburg	Health Committee
Ngotshe	Louwsburg	Town Board
	Pongolapoort	Regulated Area
Paulpietersburg	Dumbe	Town Committee
	Paulpietersburg	Borough
Pietermaritzburg	Albert Falls	Development Area
	Ashburton	Development Area
	Fox Hill	Regulated Area
	Hilton	Town Board
	Mount Michael	Health Committee
	Pietermaritzburg	Borough
	Plessislaer	Development Area
	Sobantu	Town Committee
Pinetown	Everton	Health Committee
	Gillitts	Town Board
	Hillcrest	Town Board
	Klaarwater	Black Development Area
	Kloof	Borough
	Langefontein	Development Area
	Lower Langefontein	Development Area
	Mariannhill	Health Committee
	New Germany	Borough
	Pinetown	Borough
	St Wendolins	Black Development Area

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
Pinetown (continued)	Waterfall	Town Board
	Westville	Borough
Polela	Bulwer	Development Area
Port Shepstone	Albersville	Regulated Area
	Armadale	Development Area
	Bendigo	Town Board
	Bevro	Development Area
	Cragadour	Development Area
	Marburg	Town Board
	Margate	Borough
	Marina Beach	Health Committee
	Merlewood	Development Area
	Munster	Health Committee
	Palm Beach	Development Area
	Port Edward	Town Board
	Port Shepstone	Borough
	Portview	Regulated Area
	Ramsgate	Town Board
	San Lameer	Development Area
	Shelly Beach	Town Board
	Southbroom	Health Committee
	Trafalgar	Development Area
	Umtentweni	Town Board
	Uvongo	Borough
Richmond	Living Waters	Regulated Area
	Richmond	Town Board
Ubombo	Mkuze	Development Area
Umvoti	Enhlalakahle	Town Committee
	Greytown	Borough

Table J38: Some urban areas in Natal, 1993 (continued).

Magisterial district	Urban area	Status
Umzinto	Bazley	Development Area
	Clansthal	Development Area
	Craigieburn	Development Area
	Darlington	Regulated Area
	Elysium	Development Area
	Hibberdene	Town Board
	Ifafa Beach	Development Area
	Ifafa Lagoon	Development Area
	Mtwalume	Development Area
	Ocean View	Development Area
	Park Rynie	Development Area
	Pennington	Town Board
	Saiccor Township	Health Committee
	Scottburgh	Borough
	Shayamoya	Local Authority Committee
	Sunny Brae	Regulated Area
	Umkomaas	Town Board
	Umzinto	Development Area
	Umzinto North	Town Board
	Widenham	Health Committee
	Willow Glen	Development Area
	Woodland Lodge	Regulated Area
Underberg	Himeville	Health Committee
	Pevensey	Regulated Area
	Underberg	Health Committee
Utrecht	Utrecht	Borough
Vryheid	Bhekuzulu	Town Committee
	Vryheid	Borough
Weenen	Weenen	Town Board
	Weenen	NPA Emergency Camp

Source: (i) After Ardington, E.M., 1989. Rural towns and basic needs, Rural Urban Studies Working Paper No. 20, Centre for Social and Development Studies, University of Natal, Durban, 91 p. (Separate maps are available).

(ii) After the Development and Services Board, Pietermaritzburg, 1993.

(iii) Fieldwork.

See also: Anonymous, 1991. Standard code list for statistical regions, magisterial/census districts, cities, towns and non-urban areas, Report No. 09-90-03 (1991), Central Statistical Service, Pretoria, various pages.

Note: (i) The abbreviation "NPA" used in the table, refers to the Natal Provincial Administration.

(ii) Certain urban areas are situated in more than one magisterial district. See Anonymous (1991 - above) for further details. Some large black urban areas have been divided into two or more separate administrative units, often controlled by different authorities. One example is Klaarwater.

(iii) Major (proclaimed) urban towns formerly administered by the Department of Development Aid and now administered by the Community Services Branch, Natal Provincial Administration include Clermont, the Edendale Complex (Ashdown, Edendale, Edendale East and Imbali), Inanda-Newtown, KwaDabeka and Ohlange (with the exception of the Edendale Complex - all in the Durban Functional Region); and Nondweni in the environs of Nqutu. (All the towns are partly or fully situated on former South African Development Trust land). Clermont, Edendale and KwaDabeka are now mainly in Natal, while Inanda-Newtown and Ohlange are both in the KwaZulu district of Ntuzuma. Nondweni is in the KwaZulu district of Nquthu.

(iv) Over 300 informal settlements are found in Natal/KwaZulu. The situation is highly complex and data are not readily available*. The above table is therefore incomplete. In terms of the provision of services, all black urban areas of a given size situated outside KwaZulu, are under the ultimate control of the Community Services Branch, the Development and Services Board, or an adjacent white local authority (the only instance of the latter is Greater Klaarwater - including St Wendolins - controlled by the Pinetown Municipality). Note: The Department of National Health and Population Development does not provide "hard services", except for clinics (see the discussion later in this section).

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* For a brief discussion, with a map, plus a listing of some informal (as well as formal) settlements in Natal/KwaZulu see Hindson, D. and McCarthy, J. (eds), 1994. Here to Stay: Informal Settlements in KwaZulu-Natal, Indicator Press, Durban, 230 p.

(v) Readers requiring information on urban areas in the Durban Functional Region are referred to reports in the bibliographic database as well as relevant maps (see the chapter on maps in this publication), produced inter alia by the Inkatha Institute for South Africa and the (defunct) Urban Foundation. These reports and maps are of particular importance in understanding the complexities of the Durban Functional Region, and the locality of the various urban areas (such as Lamontville and Chesterville in Natal).

(vi) Changes in land ownership (both present and historical) are sometimes discussed in the following publications: Afra News (formerly Afra Newsletter), No. 1, 1988 - current, published by the Association for Rural Advancement, P O Box 2517, Pietermaritzburg, 3200; Land Info, VOL 1(1), September 1994 - current, published by the (post-1994 election) Department of Land Affairs, Private Bag X833, Pretoria, 0001, and finally, Land Update, No. 1, May 1990 - current, published by the National Land Committee, P O Box 30944, Braamfontein, 2017. See also, Platzky, L. and Walker, C., 1985. The Surplus People: Forced Removals in South Africa, Ravan Press, Johannesburg, 446 p. Further changes in rural and urban land ownership can be expected, following the deliberations of the Commission on Restitution of Land Rights (KwaZulu-Natal), Private Bag X9120, Pietermaritzburg, 3200, from whence specific particulars can be obtained. Claims refer to any action taken after 1913 (in terms of the since repealed Natives', subsequently, Black Land Act No. 27 of 1913 and related legislation). The Commission falls under the jurisdiction of the Department of Land Affairs, and operates inter alia in terms of the Restitution of Land Rights Act No. 22 of 1994. It is important to note that an understanding of land ownership issues will not only assist the reader to interpret the literature (as discussed at the beginning of this section), but will also be of benefit in understanding the type/s of water and sanitation systems provided in given areas. Retrieval of, for instance, reticulation network, borehole and springs data according to the responsible agency, is thereby facilitated.

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areas. The Development Trust and Land Act No. 18 of 1936 "released" further land for black occupation and established the (former) South African Development Trust. The Trust was charged with acquiring additional land for black occupation, which was to be developed. Much of the released and scheduled land was transferred to KwaZulu with the granting of self-government to that territory. Several SADT areas (both rural and urban) remained, and there are a number of towns on (former) SADT land situated in or adjacent to KwaZulu, which have not yet been transferred to KwaZulu. Transfer will only occur when these areas are sufficiently developed. Services on SADT land were provided by the (former) Department of Development Aid. Townships in these areas (and hamlets - as noted above), are presently administered in terms of Proclamations and Government Notices issued under Act No. 38 of 1927.

A second category of land includes black owned (freehold title) land such as Cornfields, Matiwane's Kop and Steincoalspruit; as well as black development areas, designated areas, transit areas, emergency camps, informal settlements (including controlled legal squatter areas), and illegal squatter areas. Black development areas are found on land set aside in terms of the Black Communities Development Act No. 4 of 1984. These areas may be rural, urban or industrial and are not destined for incorporation into KwaZulu*. Black development areas are more properly referred to as "defined areas". In terms of the latter Act, the Administrator of Natal is the local authority. He in turn, appoints either a settlement officer or a township manager of the Community Services Branch of the Natal Provincial Administration. Areas controlled under Act No. 4 of 1984 include "closer settlements" which are found in the rural landscape, and consist of population concentrations at given localities. Closer settlements are not usually surveyed, planned and administered to proclaimed township standards and are thus differentiated, where for example, allocated plots are not surveyed. Closer settlements are likewise found in KwaZulu. The Community Services Branch is also responsible for the supply of services (or assistance with the supply of services), to the 17 black townships proclaimed under the Black Local Authorities Act No. 102 of 1982. (The various administrative regions and offices of the specific directorates of the Community Services Branch are listed in Table J39). Most of these townships are situated adjacent to white towns, and will soon be merged with the relevant town to form one local authority, in terms of the Interim Measures for Local Government Act No. 128 of 1991.

Designated areas (found in non-urban areas) are declared by the Administrator of Natal in terms of the Prevention of Illegal Squatting Act No. 52 of 1951. The Act enables the Community Services Branch to assume control of any area where informal settlement has

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* A useful overview of the current legal position regarding (urban type) rural settlements, both in Natal and KwaZulu, is the following: Totman, D., Pollett, E.A., A'Bear, D.R. and Murphy, C., 1994. Options for rural settlements: the planning and legal context - a <u>status quo</u> report, INR Investigational Report No. 88, Institute of Natural Resources, University of Natal, Pietermaritzburg, 32 p. See also, Bekker, J.C., 1991. Land for black housing: land tenure systems, In: Bekker, J.C., Creighton, D.V., Mavuso, J.S.A., Steyn, J.H., Strelitz, J., Treisman, S.H., Van Niekerk, G.S., Beets, H.W. and Wiechers, M., The Housing Challenge: Options and Means, Report No. ASS/BBS-22, Co-operative Programme: Affordable Social Security, Human Sciences Research Council, Pretoria, p. 23 - 35.

Table J39: Administrative regions and offices of the Directorate of Community Development and the Directorates of Physical Development (Regions 1 and 2), Community Services Branch, Natal Provincial Administration, 1993.

Region and main office location
Directorate of Community Development Headquarters Region Private Bag X9037, Pietermaritzburg, 3200
Northern Natal Region P O Box 620, Vryheid, 3100
Thukela Region P O Box 1053, Ladysmith, 3370
Zululand Region Private Bag X20095, Empangeni, 3880
Midlands Region Private Bag X9037, Pietermaritzburg, 3200
Coastal Region Private Bag X10651, Stanger, 4450 Queensburgh office: Private Bag X1, Northdene, 4064 Park Rynie office: P O Box 1405, Scottburgh, 4180
Durban Region Private Bag X54310, Durban, 4000
Directorates of Physical Development (Regions 1 and 2) Headquarters Region Private Bag X9037, Pietermaritzburg, 3200
Northern Region c/o P O Box 869, Dundee, 3000
Inland Region P O Box 17, Plessislaer, 3216
Coastal Region Private Bag X54310, Durban, 4000
Southern Region Private Bag X54310, Durban, 4000

Source: After the Community Services Branch, Natal Provincial Administration, Pietermaritzburg, 1993.

Note: (i) The above directorates are involved with the provision of services (including water and sanitation), in black settled areas controlled by the Natal Provincial Administration. The Directorate of Community Development is mainly concerned with small scale water and sanitation systems in peri-urban and rural areas.

(ii) The Directorate of Land and Housing has two offices - in Pietermaritzburg and Durban respectively. The Durban office address is Private Bag X54310, Durban, 4000, while the Pietermaritzburg office address is Private Bag X1724, Pietermaritzburg, 3200.

(iii) The Chief Directorate: Works, Private Bag X9041, Pietermaritzburg, 3200 (General Provincial Services Branch), is responsible for the construction and maintenance inter alia of hospitals, libraries, museums, the Administrator of Natal's residence, and road traffic inspectorate offices. The Directorate also controls the acquisition and disposal of land and buildings on behalf of other Natal Provincial Administration Branches.

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occurred in the absence of proper planning. Transit areas may be declared by local authorities, also by virtue of Act No. 52 of 1951, in order to take control of informal settlements within their boundaries. Emergency camps likewise, are declared in terms of Act No. 52 of 1951. The purpose of emergency camps, as the name suggests, is to provide temporary services for short periods, to those evicted from informal settlements and privately owned property. The Community Services Branch is responsible for the camps.

Informal settlements have no official standing in law and are technically illegal - until such time as they have been declared as designated or transit areas or a black development area. Services in designated and transit areas (in practical reality), may be more rapidly provided than in black development areas, in view of the population pressures evident in designated or transit areas. The Community Services Branch is responsible for services in numerous informal settlements and squatter areas on State and privately owned land. The Branch has now assumed responsibility (partly on a caretaker basis), for many SADT areas previously controlled by the (former) Department of Development Aid. The future of these areas is presently under discussion and will not be examined further*.

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* The situation was clarified in April 1994. According to the Department of Regional and Land Affairs, Pietermaritzburg, the total land area in Natal, of the (former) South African Development Trust was 510 022 ha. Approximately 260 000 ha will be transferred to the control of the Department of Agriculture for the settlement of black farmers. The remainder (mostly already settled urban land) will be transferred to the jurisdiction of the Community Services Branch. The Department of Regional and Land Affairs is the de jure owner of most of the former Department of Development Aid land.

The cities and boroughs, town boards and health committees in Natal all control their own affairs and provide the required services themselves*. Health committees can approach the Development and Services Board for technical assistance with regard to physical infrastructure, for example water supplies, if necessary. The Development and Services Board**, by virtue of the (Natal) Development and Services Board Ordinance No. 20 of 1941, currently acts as the local authority for 53 development areas and 33 regulated areas. Development areas and regulated areas are declared where the population density and/or health conditions are such that proper controls must be instituted. Regulated areas are areas falling within the provisions of the Subdivision of Agricultural Land Act No. 70 of 1970. In most of these areas incipient urbanization has already commenced or could occur. The Board's basic function is to control further undesirable or unplanned development. The Board also enforces urban local authority functions conferred by the Health Act No. 63 of 1977. Basic services are provided in regulated areas with an emphasis on potable water supplies. Development areas are recognized urban areas where normal township development is controlled. The Board is accordingly responsible for the provision and maintenance of a wide range of local authority services and infrastructure. The main objective is to upgrade development areas to the point where an independent local authority can be declared, or the area can be incorporated into an adjacent local authority. The Board likewise controls a few black residential areas, for example, the Black Development Area of Etete. The Board also controls the Trust Feed Black Development Area, where water and sanitation services are provided. The Board will in addition, act as an agent for the provision of infrastructure services in three areas being developed as black townships (the latter in terms of the Black Local Authorities Act No. 102 of 1982). These areas - classified as development areas - are Lovu, Lower Langefontein and Waterloo.

The Board on an overall basis, operates 13 waterworks, five sewage treatment plants and 39 waste disposal sites. The spectrum of areas for which the Board is responsible, ranges from industrial townships (Hammarsdale) to rural settlements. There is a possibility that

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* See Anonymous, 1989. Official South African Municipal Yearbook, Helm Publishing Company, Johannesburg, 608 p. (The publication, which is regularly updated, contains basic information on towns and cities in South Africa, including details of water and wastewater schemes).

** For an examination of the role of the Development and Services Board see: Reddy, P.S., 1991. Local government for Natal's rural areas: the Development and Services Board (1941 - 1989), Transkei Journal of Economic and Management Sciences, VOL 1(2), p. 19 - 41.

the Board will assume control (perhaps on a caretaker basis) for certain settlements in KwaZulu.

The Department of National Health and Population Development, in terms of the Health Act No. 63 of 1977, is the local authority in all areas of Natal where there is no proclaimed local authority. The responsibility of the Department in these so-called Section 30 areas is inter alia to provide advisory health services. No "hard" services (clinics excepted) are supplied. Environmental management undertaken by the Department includes water as well as sanitation and pollution in general, with an emphasis on the prevention of communicable diseases. Where development in an area passes beyond a certain point, local government responsibility is assumed by another form of local authority, which is usually the Development and Services Board. The Department will provide advice and assistance in areas controlled by a local authority, if specifically requested to do so by that authority. The final local authority is the Natal Parks Board which is empowered by virtue of the (Natal) Nature Conservation Ordinance No. 15 of 1974, to perform certain local authority functions (including health), in areas under the jurisdiction of the Board.

The Water Services Advisory Board established in terms of the (Natal) Water Services Ordinance No. 27 of 1963, was originally designated as the controlling/advisory body for the (former) Regional Water Services Corporations. The corporations became part of the Joint Services Boards in 1991. The Joint Services Boards therefore "inherited" the powers of the former corporations as described in the Ordinance. The Joint Services Boards accordingly, must make application to the Water Services Advisory Board for permission to increase tariffs, or to raise loans to finance new reticulation schemes, or to upgrade existing facilities. Certain technical (engineering) matters likewise, fall under the authority of the Advisory Board. Small local authorities can approach the Board for financial advice, and financial or technical assistance.

While the Natal Provincial Administration and the KwaZulu Government (see below), plus the two water boards in Natal, the various local authorities, the Joint Services Boards and the Department of Water Affairs and Forestry all play important roles with regard to water supplies, it is the KwaZulu/Natal Joint Executive Authority - established by the Joint Executive Authority for KwaZulu and Natal Act No. 80 of 1986 - which provides an overall liaison/co-ordinating function for the two regions. Such co-ordination includes water and other infrastructure. Co-operation is enhanced by the Republic of South Africa-KwaZulu

Permanent Water Commission (discussed earlier), which undertakes joint catchment studies and makes recommendations on the joint use and management of water. The Republic of South Africa-Transkei Permanent Water Commission is similarly involved with rivers in southern Natal. There is a future possibility of a "Natal/KwaZulu Water Board" which would provide bulk water supplies to all local authorities, as a second tier form of government. The Board's area of jurisdiction would cover the whole of Natal and KwaZulu. Local authorities would constitute the third tier of government with the Department of Water Affairs and Forestry as the first tier.

10.19.2 Local authorities and services in KwaZulu*

Two KwaZulu Government departments (Tables J40 and J41) are involved in the supply of water. The KwaZulu Department of Works provides, controls and maintains water systems at most official KwaZulu Government installations, namely, hospitals, clinics, police stations, magistrates' courts and a few non-community schools. The primary function of the Department is the supply of water to certain factories in rural and peri-urban areas, as well as household supplies in 28 proclaimed townships (Table J42) and several hamlets. Houses occupied by Government employees (outside of proclaimed townships) may also be provided with reticulated water. The Department is similarly responsible for water systems at households in closer settlements.

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* Discussion based on Alcock, P.G., 1987. Domestic water supplies in non-urban KwaZulu: existing water systems, Occasional Publication No. 8, Department of Crop Science, University of Natal, Pietermaritzburg, 100 p. See also, Anonymous, 1993. Executive summary: KwaZulu rural and peri-urban water supply and sanitation policy for the KwaZulu Government, Report No. 2424, Davies Lynn and Partners, Durban, 32 p., and Anonymous, 1993. KwaZulu rural and peri-urban water supply and sanitation policy: Phase 2 situational analysis: summary report for the KwaZulu Government, Report No. 2424, Davies Lynn and Partners, Durban, 22 p. + app. See in addition: Anonymous, 1993. Phase 3 policy formulation: KwaZulu rural and peri-urban water supply and sanitation policy for the KwaZulu Government, Report No. 2424, Davies Lynn and Partners, Durban, 85 p. + app., as well as Anonymous, 1994. Upper Nseleni water supply scheme: report for the KwaZulu Government - Phase 1: situational analysis, final draft, Report No. 2424/1, KwaZulu Finance and Investment Corporation and Davies Lynn and Partners, Durban, 33 p. + app. Summarized data on existing water and sanitation services as well as refuse disposal systems, for various urban and densely populated rural settlements are provided in Smith, G., 1993. Economic development strategies for Region E, Phase 1: socio economic analysis and assessment, Working document for input into synthesis report - infrastructure, services and utilities, Regional Development Advisory Committee - Region E, Pietermaritzburg, 50 p. + app. (The report also contains population estimates for the given settlements).

Table J40: Administrative regions and offices of the KwaZulu Department of Works.

Engineering region and main office location	Sub-offices (excluding minor depots)
Northern Region Private Bag X5030, Nongoma, 3950	Frischgewaagd; Jozini; KwaMsane; Ncotshane
Ulundi Region Private Bag X03, Ulundi, 3838	Mahlabatini
Midlands Region Private Bag X9963, Ladysmith, 3370	Ezakheni; Hlanganani; Madadeni; Mondlo; Nqutu; Osizweni; Tugela Ferry
Southern Region Private Bag X1013, Hammarsdale, 3700	Gamalakhe; KwaMakhutha; KwaMbono; Magabheni; Mfolweni; Mpumalanga
Coastal Region Private Bag X584, Eshowe, 3815	Dondotha; Esikhawini; Maphumulo; Ndwedwe; Ngwelezana; Nkandla; Nseleni; Sundumbili; Vulindlela

Source: After the KwaZulu Department of Works, Ulundi, 1993.

Table J41: Administrative regions and offices of the KwaZulu Department of Agriculture and Forestry.

Agricultural region and KwaZulu district	Regional and district offices
Mabedlana (Northern Region) Hlabisa; Ingwavuma; Mahlabathini; Nongoma; Simdlangentsha; Ubombo	Private Bag X5079, Nongoma, 3950 Hlabisa; Ingwavuma; Mahlabatini; Nongoma; Pongola; Ubombo
Ogwini (Central Region) Inkanyezi; Maphumulo; Ndwedwe; Nkandla; Nseleni; Ongoye	Private Bag X552, Eshowe, 3815 Eshowe; Maphumulo; Ndwedwe; Nkandla; Empangeni; Gingindlovu
Mpandleni (Midlands Region) Emnambithi; Madadeni; Msinga; Nquthu; Okhahlamba	Private Bag X9905, Ladysmith, 3370 Ezakheni; Osizweni; Tugela Ferry; Nqutu; Wembezi (Estcourt)
Umzansi (Southern Region) Emzumbe; Ezingolweni; Hlanganani; Mpumalanga; Umbumbulu; Vulamehlo; Vulindlela - plus Ntuzuma and Umlazi - both urban areas	Private Bag X9053, Pietermaritzburg, 3200 Mtwalume; The Ridge (Harding); Polela (Bulwer); Cato Ridge; Adams Mission (Amanzimtoti); Umzinto; KwaGubeshe (Taylor's Halt)

Source: After the KwaZulu Department of Agriculture and Forestry, Ulundi, 1993.

Note: The address of the headquarters office is Private Bag X05, Ulundi, 3838.

Table J42: Proclaimed KwaZulu townships administered by the KwaZulu Department of the Interior, 1993.

Township	KwaZulu magisterial district
Ekuvukeni	Emnambithi
Esikhawini	Ongoye
Ezakheni (A,B,C,D and E)	Emnambithi
Gamalakhe	Ezingolweni
Gezinsila	Inkanyezi
KwaMakhutha	Umbumbulu
KwaMashu	Ntuzuma
KwaMbono	Ezingolweni
KwaMsane	Hlabisa
KwaNdengezi	Mpumalanga
Madadeni	Madadeni
Magabheni	Umbumbulu
Mondlo	Nquthu
Mpophomeni	Vulindlela
Mpumalanga	Mpumalanga
Mpungamhlophe	Mahlabathini
Ncotshane	Simdlangentsha
Ndaleni	Hlanganani
Ngwelezana	Nseleni
Nseleni	Nseleni
Ntuzuma	Ntuzuma
Osizweni	Madadeni
Sundumbili	Inkanyezi
Ulundi	Mahlabathini
Umlazi	Umlazi
Vulandondo	Emnambithi
Vulindlela	Ongoye
Wembezi	Okhahlamba

Source: After Nicholson, C.R. and Jenkin, F., 1992 (on-going). The Laws of KwaZulu: a Compilation of All the Acts, Regulations, Proclamations and

Government Notices Relating to the Self-governing Territory of KwaZulu, VOL 2, Metis Publications Law Service, Durban, various pages.

See also:

(i) Anonymous, 1991. Standard code list for statistical regions, magisterial/census districts, cities, towns and non-urban areas, Report No. 09-90-03 (1991), Central Statistical Service, Pretoria, various pages.

(ii) Jenkin, F.J.D. (ed), 1993 (on-going). Townships and Rural Land Within KwaZulu, Metis Publications Law Service, Durban, various pages.

Note:

(i) Some of the numerous villages and settlements in KwaZulu, and (former) Department of Development Aid townships as well as hamlets (as at 1986), are listed in the following document: Anonymous, 1988. KwaZulu development information, VOL 1 - 2, various pages, Government of KwaZulu and the Development Bank of Southern Africa, Halfway House. (The publication contains data on infrastructure services including water and sanitation for proclaimed townships).

(ii) Urban towns (hamlets) in KwaZulu administered by the Natal Townships Board include Hlabisa; Ingwavuma; Mahlabatini; Nkandla; Nqutu; Pomeroy (Msinga District); Somkele (Hlabisa District); Ubombo, and Umbumbulu. Towns administered by their own town boards are Impendle (Hlanganani District) and Nongoma. Services are provided on behalf of the Townships Board and both town boards by the Community Services Branch, Natal Provincial Administration. Other urban areas (however defined) include the Limehill Complex (a closer settlement) and Jozini (the latter only partly administered by KwaZulu).

(iii) Many informal settlements are evident in the Durban Functional Region. The situation is complex and data are not readily available. (See Footnote (iv) of Table J38).

The Department of Works was involved in the provision of infrastructure including water in a number of KwaZulu townships, in conjunction with the (former) Department of Development Aid. These programmes were undertaken via the RSA-KwaZulu Development Project (discussed in the chapter on water supply planning, elsewhere in this publication). The Community Services Branch of the Natal Provincial Administration has now assumed the functions in these areas, of the Department of Development Aid. Umgeni Water (with the assistance of the KwaZulu Department of Works - where relevant), instituted a programme in 1981 to install reticulated supplies in certain black residential areas in the Durban Functional Region, and subsequently further afield. Mhlatuze Water has likewise begun to address formal reticulated systems in black settled areas in northern KwaZulu. A regional (rural) water scheme has been completed at Ndumo and environs, which will ultimately serve some 50 000 people in a 570 km^2 area. Further reticulation networks are planned in the vicinity of Hluhluwe Dam and the Makatini Flats.

The KwaZulu Department of Works is also responsible for sanitation services including the removal of refuse (where applicable), in proclaimed townships and at Government buildings. A recent trend is the privatisation of waterworks and sewage treatment works in selected townships. Refuse removal and disposal likewise, has been privatised in several townships.

The second KwaZulu Government department concerned with water supplies is the KwaZulu Department of Agriculture and Forestry. The Department is involved with the upgrading of potable water sources as well as irrigation and related services, at agriculturally-based settlements (both rural and peri-urban) in KwaZulu. Potable sources are mainly in the form of protected springs, boreholes and wells (see the chapter on groundwater). The Department is officially responsible for the drilling of boreholes and wells in non-urban areas of KwaZulu. The Department employs a contractor to undertake actual drilling operations. The Department may also, if requested by the KwaZulu Department of Works, arrange for the drilling of boreholes in proclaimed townships and hamlets. These areas are not however, usually dependent on boreholes. The KwaZulu Department of Works may also request drilling services at Government buildings such as clinics, in rural areas. The KwaZulu Department of Works is then responsible for the installation and maintenance of pumping facilities at the sites. The KwaZulu Department of Agriculture and Forestry maintains borehole pumping equipment in all other areas, with the exception of the Umzansi agricultural region and boreholes installed by non-KwaZulu

Government agencies. All maintenance costs (where relevant), are borne by the Department. Several non-government organizations have undertaken the upgrading of water sources, especially springs, in non-urban areas of KwaZulu and in a few SADT areas. The Natal Parks Board is involved with the provision (facilitation) of services - including water supplies and sanitation - in black rural areas bordering conserved land*. The KwaZulu Department of Health (with special reference to rural and peri-urban areas), provides advice on health matters and undertakes a monitoring and evaluation function in terms of communicable diseases, sanitation and other services**.

10.19.3 Joint Services Boards in Natal/KwaZulu

Joint Services Boards (JSBs), known as Regional Services Councils in the other provinces, were established in terms of the KwaZulu and Natal Joint Services Act No. 84 of 1990. The main purpose of the JSBs is to provide bulk services across political and administrative boundaries within a given geographic area, thereby promoting planning and operational efficiency. Services may include water supplies, sanitation, fire fighting, solid waste management, the construction of community facilities such as clinics, and tourism. The seven former Regional Water Services Corporations (RWSCs) now form part of the various Joint Services Boards. The Pinetown, North Coast and Amanzimtoti RWSCs were incorporated in the Port Natal/Ebhodwe JSB, with the Lower South Coast and Umzinto RWSCs, now part of the Southern Natal JSB. The North East Zululand RWSC was incorporated in the Zululand JSB. The Dundee-Glencoe RWSC in turn, was incorporated in the Thukela JSB. The amalgamation took effect in 1991. It should be noted that the JSBs place a high priority on the provision of water supplies in black settled areas. Table J43 lists all the Joint Services Boards in Natal/KwaZulu, with their constituent local

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* The Independent Development Trust, P O Box 16114, Vlaeberg, 8018, has funded over 130 development projects including water schemes in rural Natal/KwaZulu in the last few years. Some informal project-related training was provided.

** See Alcock, P.G., Rivett-Carnac, J.L. and Fourie, K.J., 1988. Current status of water supply and sanitation in rural and peri-urban areas of KwaZulu, Paper No. 2.2, Seminar on Water Supply and Sanitation - KwaZulu, South African National Committee of the International Water Supply Association, the Division of Water Technology of the CSIR, the KwaZulu Government and the Department of Development Aid, 28 - 30 June 1988, Durban, 32 p.

authorities*. Brief data on Joint Services Boards' infrastructure services are provided in Table J44.

Table J43: Joint Services Boards in Natal/KwaZulu with their constituent local authorities, 1993.

Joint Services Board	Constituent local authorities
East Griqualand Joint Services Board, P O Box 8, Kokstad, 4700	
Town Councils	Kokstad and Matatiele
Town Board	Cedarville
Local Affairs Committees	Cedarville; Kokstad and Matatiele
Town Committees	Bhongweni and Itsokolele
Local Authority Committee	Mzingisi
Natal Midlands Joint Services Board, P O Box 3235, Pietermaritzburg, 3200	
City Council	Pietermaritzburg
Town Councils	Greytown; Howick and Mooi River
Town Boards	Hilton; Richmond and Weenen
Health Committees	Ashburton; Camperdown; Creighton; Dalton; Himeville; Impendle; Ixopo; Kranskop; Mount Michael; Mpolweni; New Hanover; Underberg and Wartburg
Local Affairs Committees	Greytown (Indian); Greytown (Coloured); Howick (Indian); Howick (Coloured); Ixopo; Mooi River; Pietermaritzburg (Indian); Pietermaritzburg (Coloured) and Richmond (Indian)
Town Committees	Bruntville; Enhlalakahle and Sobantu
Local Authority Committee	KwaMevana
KwaZulu Regional Authorities	Hlanganani; Izindhlovu; Mpumalanga; Msinga; Nkandla and Vulindlela

* The Joint Services Boards were disbanded on the 1st of August 1996, and were replaced by Regional Councils (RCs). There are seven councils as follows: iLembe Regional Council, P O Box 1520, Durban, 4000; iNdlovu Regional Council, P O Box 3235, Pietermaritzburg, 3200; uMzinyathi Regional Council, P O Box 1965, Dundee, 3000; uThukela Regional Council, P O Box 116, Ladysmith, 3370; uThungulu Regional Council, Private Bag X1025, Richards Bay, 3900; Ugu Regional Council, P O Box 33, Port Shepstone, 4240, and the Zululand Regional Council, Private Bag X76, Ulundi, 3838. Note that part of the area administered by the former Port Natal/Ebhodwe Joint Services Board, was transferred to a new structure known as the Durban Transitional Metropolitan Council. The remainder of this (former) JSB area falls under the jurisdiction of the iLembe Regional Council.

Table J43: Joint Services Boards in Natal/KwaZulu with their constituent local authorities, 1993 (continued).

Joint Services Board	Constituent local authorities
Township Councils (formerly under the control of the Department of Development Aid - now the Community Services Branch, Natal Provincial Administration)	Ashdown; Edendale and Imbali
Development Areas	Albert Falls; Bulwer; Cool Air; Fort Nottingham; Lidgetton West; Plessislaer and Trust Feed
Regulated Areas	Boston; Cramond; Fox Hill; Harburg; Living Waters; Manderston; Midmar; Mount Dragon; Pevensey; Sierra Ranch; Stuartsville; Thornville and Umlaas Road
Port Natal/Ebhodwe Joint Services Board, P O Box 1520, Durban, 4000	
City Council	Durban
Town Councils	Amanzimtoti; Ballitoville; Isipingo; Kingsburgh; Kloof; New Germany; Pinetown; Queensburgh; Stanger; Umhlanga Rocks; Verulam and Westville
Town Boards	Gillitts; Hillcrest; Tongaat; Umbogintwini; Umdhloti Beach; Umhlali Beach and Waterfall
Health Committees	Assagay; Blythedale Beach; Botha's Hill; Canelands; Cato Ridge; Darnall; Drummond; Everton; Lower Illovo; Mariannhill; Shakaskraal; Yellowwood Park and Zinkwazi Beach
Local Affairs Committees	Durban Grey Street; Northern Durban; Southern Durban; Durban (Coloured); Pinetown (Indian); Stanger (Indian); Westville and Wyebank
Town Committees	Hambanathi and Ningizimu
Local Authority Committees	Klaarwater and Shakaville
KwaZulu Regional Authorities	Izindhlovu; Mpumalanga; Ndwedwe and Sobonakhona
KwaZulu Township Councils	KwaMakhutha; KwaMashu; Mpumalanga; Ntuzuma and Umlazi
Township Councils (formerly under the control of the Department of Development Aid - now the Community Services Branch, Natal Provincial Administration)	Clermont; Inanda and KwaDabeka

Table J43: **Joint Services Boards in Natal/KwaZulu with their constituent local authorities, 1993 (continued).**

Joint Services Board	Constituent local authorities
Development Areas	Craiglea; Duff's Road; Etete; Hammarsdale; Inchanga; Inchanga West; Langefontein; Lovu; Lower Langefontein; Mount Moreland; Ottawa; Port Zimbali; Prince's Grant; Redcliffe; Riet Rivier; Shallcross; Sterkspruit; Tinley Manor Beach; Tugela; Waterloo and Welbedagt
Regulated Areas	Blackburn; Buffels Draai; Cliffdale; Harrison and Hazelmere
Southern Natal Joint Services Board, P O Box 33, Port Shepstone, 4240	
Town Councils	Margate; Port Shepstone; Scottburgh; Shelly Beach and Uvongo
Town Boards	Bendigo; Harding; Hibberdene; Marburg; Munster; Pennington; Port Edward; Ramsgate; Southbroom; Umkomaas; Umtentweni and Umzinto North
Health Committees	Marina Beach; Saiccor Township and Widenham
Local Affairs Committees	Craigieburn and Harding
Local Authority Committee	Shayamoya
KwaZulu Regional Authorities	Emzumbe; Vulamehlo and Zamukukhanya
KwaZulu Township Councils	Gamalakhe and Magabheni
Development Areas	Armadale; Bazley; Bevro; Clansthal; Cragadour; Craigieburn; Elysium; Ifafa Beach; Ifafa Lagoon; Merlewood; Mtwalume; Ocean View; Palm Beach; Park Rynie; San Lameer; Trafalgar; Umzinto and Willow Glen
Regulated Areas	Albersville; Darlington; Portview; Sunny Brae and Woodland Lodge
Thukela Joint Services Board, P O Box 116, Ladysmith, 3370	
Town Councils	Bergville; Colenso; Dundee; Estcourt; Glencoe; Ladysmith; Newcastle and Utrecht
Town Board	Dannhauser
Health Committees	Hattingspruit; Talana and Winterton

Table J43: Joint Services Boards in Natal/KwaZulu with their constituent local authorities, 1993 (continued).

Joint Services Board	Constituent local authorities
Local Affairs Committees	Colenso; Dannhauser; Dundee (Indian); Dundee (Coloured); Estcourt (Indian); Glencoe; Ladysmith (Indian); Newcastle (Indian); Newcastle (Coloured); Utrecht and Weenen
Town Committees	Nkanyezi; Sibongile; Sithembile and Steadville
KwaZulu Regional Authorities	Emnambithi; Inhlanganiso; Madadeni and Nqutu
KwaZulu Township Councils	Ezakheni; Madadeni; Osizweni and Wembezi
Development Areas	Charlestown; Driefontein and Wasbank
Regulated Areas	Cathkin Park; Chelmsford; Drystream; Rietkuil; Spioenkop and Wagendrift
Zululand Joint Services Board, Private Bag X1025, Richards Bay, 3900	
Town Councils	Empangeni; Eshowe; Paulpietersburg; Richards Bay and Vryheid
Town Boards	Gingindlovu; Louwsburg; Mandini; Melmoth; Mtunzini and St Lucia
Health Committees	Kranskop and Mtubatuba
Local Affairs Committees	Gingindlovu (Indian); Gingindlovu (Coloured); Mpushini Park; Mtubatuba (Indian); Mtubatuba (Coloured); Richards Bay (Indian); Richards Bay (Coloured); Sunnydale and Vryheid
Town Committees	Bhekuzulu and Dumbe
KwaZulu Regional Authorities	Enseleni; Hlabisa; Ingwavuma; Inkanyezi; Lindidlela; Mashonangashoni; Mehlwesizwe; Nkandla; Nongoma; Nqutu and Simdlangentsha
KwaZulu Township Councils	Esikhawini; Gezinsila; Ncotshane; Ngwelezana; Nseleni; Sundumbili and Ulundi
Township Council (formerly under the control of the Department of Development Aid - now the Community Services Branch, Natal Provincial Administration)	Nondweni
Development Areas	Hluhluwe; KwaMbonambi; Mkuze and Tugela Mouth
Regulated Areas	Mangete; Pongolapoort and Umlalazi

Source: (i) After Jenkin, F. (ed), 1990 (on-going). KwaZulu/Natal Joint Services Act 1990 and Regulations, Metis Publications Law Service, Durban, various pages.

(ii) Fieldwork.

See also: Bekker, S.B., 1990. Durban city government in the Nineteen-nineties: the Joint Services Board and its possible future, Urban Forum, VOL 1(2), p. 1 - 14.

Note: (i) The boundaries of each Joint Services Board region are described in the relevant Natal Provincial Notice namely, No. 53/91; No. 52/91; No. 50/91; No. 51/91; No. 54/91 and No. 49/91 (following the order of presentation above).

(ii) There are approximately 202 tribal authorities in KwaZulu; seven community authorities (consisting of one or more tribes or communities) with generally the same powers as tribal authorities; and several regional authorities - both rural and urban - composed of two or more tribal authority areas, with somewhat advanced (regional) powers and functions.

10.20 Civil defence (now known as civil protection) in Natal/KwaZulu

In terms of the Civil Defence Act No. 67 of 1977, the then Provincial Councils were granted the power to make Ordinances with regard to civil protection in a state of emergency or a disaster, for example, severe flooding or a major industrial accident*. In Natal, various regulations under the Act, plus the (Natal) Civil Defence Ordinance No. 5 of 1978, enable municipalities (local authorities) to prepare disaster planning routines and procedures. Specific provision is made for voluntary civil protection organizations in areas falling outside municipal boundaries. For the purposes of civil protection, these voluntary organizations are deemed to be local authorities for their own areas. It should be noted that Joint Services Boards in Natal are now responsible for the facilitation of civil protection in their respective areas of operation. The Directorate of Auxiliary Services,

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* A seldom envisaged aspect of flood management is the need for both short and longer term psychological treatment of flood victims (those who have lost property, or friends and relatives). Few organizations in this country are able to undertake the professional counselling of flood victims, and the available South African literature is sparse (see the bibliographic database). The Department of Medically Applied Psychology, Medical School, University of Natal, Private Bag 7, Congella, 4013, has considerable expertise in this regard, and was involved in the September 1987 floods in Natal/KwaZulu.

Table J44: Some relevant statistics for Joint Services Boards in Natal/KwaZulu, 1992.

Joint Services Board	Supply area (km^2)	Population served (million)	Water services			Wastewater services	
			supply area (km^2)	capacity of schemes ($k\ell\ day^{-1}$)	storage capacity ($k\ell$)	service area (km^2)	capacity of schemes ($k\ell\ day^{-1}$)
East Griqualand	3 920	0,04	-	-	-	-	-
Natal Midlands	18 569	1,5	-	-	-	-	-
Port Natal/Ebhodwe	5 322	2,9	757	357 150	220 299	203	4 000
Southern Natal	5 270	0,6	326	61 700	83 580	28	4 600
Thukela	28 074	1,1	585	89 500	94 500	-	-
Zululand	39 431	1,9	500	7 980	22 500	-	-

Source: After Anonymous, 1992. Association of Joint Services Boards annual report 1991/92, Association of Joint Services Boards, [Durban], 16 p.

Note: Joint Services Boards were established in 1991. The table therefore reflects only one year of operation.

Chief Directorate: Administration, General Provincial Services Branch, Natal Provincial Administration, Private Bag X9037, Pietermaritzburg, 3200, is responsible for the overall co-ordination of civil protection on a province-wide basis (excluding KwaZulu). A comprehensive disaster contingency plan for Natal has been prepared by the Directorate*. Local authorities however, are responsible for day-to-day civil protection duties. (Contact the Chief Civil Protection Officer of the nearest local authority for specific details). There are 129 civil protection organizations (including municipalities) in Natal (Table J45). In KwaZulu, township councils are the relevant local authority in terms of the KwaZulu Civil Defence Act No. 11 of 1984. In areas outside these townships, the magistrate of the district concerned is the local authority.

<u>**For further information consult the following:**</u>

- Adam, A.S., 1985. The administration of civil defence at local government level in South Africa, M.P.A. Thesis, Faculty of Commerce and Administration, University of Durban-Westville, Durban, 312 p.

- Anonymous, undated. Alert: the comprehensive guide to community safety, Medical Association of South Africa, Cape Town, 72 p.

- Potgieter, H.P., 1980. Burgerlike beskerming, Publication No. 7, Institute for Strategic Studies, University of Pretoria, Pretoria, 128 p.

- Smit, A. de V., 1981. South African civil defence organization and administration with particular reference to the Cape Peninsula, M.P.A. Thesis, [Department of Public Administration], University of Cape Town, Rondebosch, 256 p.

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* A disaster management co-ordinating centre involving several agencies was recently established for Natal/KwaZulu as a unified region. The purpose of the centre is to plan and co-ordinate all major relief operations for both natural and man-made disasters. Organizations represented include the South African Defence Force; the South African Police; ESKOM; the Ambulance and Emergency Medical Services; Medical Rescue International; Umgeni Water/Department of Water Affairs and Forestry; the Roads Branch of the Natal Provincial Administration; the Natal Provincial Road Traffic Inspectorate, and the Directorate of Auxiliary Services (Natal Provincial Administration).

Table J45: Civil protection organizations (including municipalities) in the Joint Services Board areas of Natal, 1993.

Joint Services Board area	Local authority
East Griqualand Joint Services Board	Bhongweni; Cedarville; Itsokolele; Kokstad; Matatiele and Swartberg/Franklin
Natal Midlands Joint Services Board	Ashburton; Beaumont/Eston; Boston; Bruntville; Camperdown; Cramond/New Hanover; Creighton; Dalton; Enhlalakahle; Greater Bishopstowe; Greytown; Hilton; Howick; Ixopo; KwaMevana; Midmar; Mooi River; Mooi River District; Mount Michael; Nottingham Road; Pietermaritzburg; Richmond; Sobantu; Umvoti; Underberg/Himeville and Wartburg
Port Natal/Ebhodwe Joint Services Board	Amanzimtoti; Ballitoville; Botha's Hill; Cato Ridge; Darnall; Drummond; Durban; Gillitts-Everton; Hambanathi; Hillcrest; Isipingo; Kingsburgh; Kloof; Lower Illovo; Lower Tugela; Mount Edgecombe; New Germany; Ningizimu; Pinetown; Queensburgh; Shakaville; Shayamoya; Stanger; Tongaat; Umbogintwini; Umdhloti Beach; Umhlali Beach; Umhlanga Rocks; Verulam; Westville; Yellowwood Park and Zinkwazi Beach
Southern Natal Joint Services Board	Harding; Hibberdene; Hibberdene/Mtwalume; Izotsha; Marburg; Margate; Marina Beach; Munster; Paddock and Plains; Pennington; Port Edward; Port Shepstone; Ramsgate; San Lameer; Scottburgh; Shelly Beach; Southbroom; Umkomaas; Umzinto North; Umzumbe and Uvongo
Thukela Joint Services Board	Bergville; Besters/Van Reenen; Bushmans River; Colenso; Dannhauser; Dundee; Dundee District; Elandslaagte; Estcourt; Glencoe; Hattingspruit; Ladysmith; Newcastle; Newcastle District; Nkanyezi; Sibongile; Sithembile; Steadville; Utrecht; Utrecht District; Weenen and Winterton
Zululand Joint Services Board	Bhekuzulu; Central Zululand; Dumbe; Empangeni; Eshowe; Gingindlovu; Hluhluwe/Mkuze; KwaMbonambi; Mandini; Melmoth; Mtubatuba; Mtunzini; Ngotshe; Nkwaleni; Ntumeni; Paulpietersburg; Richards Bay; Richards Bay/Empangeni; St Lucia; Umfolozi; Vryheid and Vryheid District

Source: After the Directorate of Auxiliary Services, Chief Directorate: Administration, General Provincial Services Branch, Natal Provincial Administration, Pietermaritzburg, 1993.

See also: Meyer, J., 1983 (on-going). Local Government Law VOL 3, Law Enforcement, Security and Civil Defence, Butterworths, Durban, various pages.

Note: Thirteen local authorities have extended their areas of jurisdiction to include adjacent rural areas. The local authorities are: Ashburton, Bergville, Creighton, Drummond, Harding, Howick, Ixopo, Munster, Paulpietersburg, Port Edward, Richmond, Weenen and Winterton.

- Van der Westhuizen, J. (ed), 1986. Management course in civil defence: Part 1 - strategy, Institute for Criminology, University of South Africa, Pretoria, various pages.

- Van der Westhuizen, J. (ed), 1986. Management course in civil defence: Part 2 - tactical issues, Institute for Criminology, University of South Africa, Pretoria, various pages.

- The following conference proceedings contain several papers of interest:

  Second National Conference of the Civil Defence Association of South Africa, 8 - 9 September 1987, Bloemfontein.

  Third National Conference of the Civil Defence Association of South Africa, 29 - 30 September 1988, Durban (entire issue devoted to flood studies).

  Fourth National Conference of the Civil Defence Association of South Africa, 28 - 29 September 1989, Bellville.

  Sixth National Conference of the Civil Protection Association of South Africa, 23 - 24 September 1993, Nelspruit.

  Eighth Annual General Meeting of the Civil Protection Association of South Africa, 3 - 4 September 1992, Bloemfontein.

The conference papers are available from the Civil Protection Association of South Africa (now known as the Emergency and Disaster Management Association of Southern Africa)*, c/o the Chief Civil Protection Officer, Pietermaritzburg Municipality, P O Box 321, Pietermaritzburg, 3200; or the offices of Civil Protection at the larger municipalities in South Africa; or the National Civil Protection Committee, Department of Local Government and National Housing, Private Bag X644, Pretoria, 0001. (Note: The previous emphasis was on civil defence rather than civil protection. The latest terminology refers to disaster planning/management or risk reduction - see the chapter on rainfall, elsewhere in this publication).

10.20.1 The severe weather watch service for South Africa**

The Weather Bureau, Private Bag X097, Pretoria, 0001, operates a severe weather watch service for South Africa. The service includes two forecasts, namely, 12 - 48 hour forecasts or outlook forecasts (warning that severe weather may develop in a given region), and two hour alerts (nowcasts). The former is a national forecast which is usually issued by the Pretoria office of the Weather Bureau, and is released to the South African Broadcasting Corporation for dissemination via radio and television. Outlook forecasts consist of various categories such as special aircraft forecasts (airports); shipping forecasts (gales, swells and fog); agricultural forecasts (excessive cold with special reference to the Angora goat farmers of the eastern Cape, frost and black frost); forestry forecasts (possibility of fires), and general public forecasts of heavy rain (including cyclone warnings for Natal/KwaZulu and Swaziland). Other types of forecasts include notice of very high heat discomfort index conditions (Natal/KwaZulu in particular); severe thunderstorms (especially in the southern Transvaal); flood warnings, and warnings of widespread cold weather and/or snow.

Two hour alerts concern the identification of (developing) dangerous weather conditions (for example, the "Black south-easter" of the Cape Province - more correctly termed a cut-

* The head office address of the new Association is: P O Box 1703, Krugersdorp, 1740.

** Discussion based on Laing, M., 1987. A severe weather watch service for South Africa, Second National Conference of the Civil Defence Association of South Africa, 8 - 9 September 1987, Bloemfontein, p. 29 - 33. (The United Nations has declared the 1990s as the International Decade for Natural Disaster Reduction - IDNDR. Natural disasters of particular interest include the instability of major metropolitan areas; landslides; volcanic activity; earthquakes; tropical cyclones, floods and droughts).

off low - *responsible inter alia for the Laingsburg floods of 1981); and forecasting of the* movement, duration and intensity of the severe weather system. These forecasts are specifically prepared to warn the civil protection authorities that a given system is imminent, thereby providing information on the type and extent of damage which can be expected. Regular updated warnings are issued for the civil protection authorities and the public.

The Weather Bureau recently introduced a coding system for severe weather conditions. A "green day" indicates that no severe system (based on forecasting data as well as models), is anticipated during the next 24 hours. There is however, a possibility of severe conditions developing on a "yellow day". An orange warning is issued once a severe weather system has been identified, and is being watched. A red warning implies that the system will take effect within 2 - 3 hours. Depending on the speed with which the system develops, it is possible (in extreme situations) to change status from a yellow day to a red warning, within a short period of time.

10.20.2 The flood relief scheme for flood disaster areas

Severe flood damage is an infrequent, although recurring event in South Africa. With the exception of the January 1981 Laingsburg floods which were locality-specific, the first major widespread flooding resulting in serious damage and the loss of life (in very recent times), occurred in September 1987 in Natal/KwaZulu. A flood relief scheme was drawn up in response to the latter floods. It is instructive to briefly examine the scheme as a benchmark case study. (The scheme was used in toto for example, with regard to the October 1991 floods in the Calvinia Magisterial District)*. The flood relief scheme was established by Government Regulation Notice GN R47/88 (in terms of Section 8 read with Section 9 of the Conservation of Agricultural Resources Act No. 43 of 1983)**, whereby white-owned agricultural land in Natal per se, was declared a flood disaster area. Flood damage was defined as damage to the natural agricultural resources as well as soil conservation works. The objective of the flood relief scheme was to repair flood damage using subsidies approved by Parliament. The scheme was not intended to recreate (at all

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* See Government Regulation Notice GN R2771/92, published in the Republic of South Africa Government Gazette No. 14304 of the 2nd October 1992.

** See Anonymous, 1988. Republic of South Africa Government Gazette No. 11097 of the 15th January 1988, Government Printer, Pretoria, 28 p.

costs), the situation prevailing before the floods. The scheme was valid for a period of 30 months, effective from the 1st of October 1987.

In order to qualify for the subsidy, a particular farm unit had to be situated in the flood disaster area. Secondly, only those farm units which were recognized by the then Department of Agriculture and Water Supply (now the Department of Agriculture), as having suffered flood damage, were eligible for the subsidy. Documentary proof of flood damage accompanied by a map indicating the areal extent of the damage, plus other relevant information, was required. Applicants were given six months in which to register for the scheme. No flood repairs, for which a subsidy was requested, could be undertaken prior to consent by the Department. The only exception was the repair of damage to fences and stock watering systems essential for the continuation of farming activities. These repairs could be made immediately after the subsidy application had been lodged. Written consent from the Department specified the repairs which could be undertaken, as well as the materials needed (for which invoices had to be obtained and submitted to the Department). The consent included plans and specifications in accordance with which the subsidized repairs had to be undertaken. Land users were also entitled to submit their own plans and specifications. If these proposals were accepted by the Department, then the damage was to be repaired as per the plans submitted.

The Department had to be notified once the subsidized repairs had been completed (within the stipulated period according to the consent). Failure to notify the Department could have resulted in a refusal to pay any subsidy, or a postponement of payment. Where flood damage was unlikely to be repaired within the consent period, the Department was empowered to extend that period (on application by the land user), provided that the maximum period of 30 months was observed. Notification of the completion of repairs by the land user, included a written statement providing the exact dimensions and specifications of the repairs undertaken, in accordance with the agreed plans. Repairs were required to be functional (where applicable). Confirmation was also needed that the repairs had been undertaken using new materials, except where otherwise permitted. Alternatively, Departmental staff were required to inspect the farm unit and to compile a report on the repairs. Inspection of the repairs could be carried out either before or after the subsidy had been paid.

If it became evident that the repairs had not been undertaken in accordance with the agreed plans, or that the repairs did not qualify for a subsidy for any other reason, then no subsidy was payable until the issue had been resolved. Where the land user had received flood assistance by means of a loan in terms of the Agricultural Credit Act No. 28 of 1966, the subsidy was used as payment or part payment of the amount (plus interest), due to the State as a result of such assistance. If it became apparent that no subsidy should have been paid for repairs, or that the dimensions and specifications of the repairs claimed to have been undertaken were incorrect (and that the amount paid as subsidy exceeded the amount that was lawfully payable as subsidy), then the land user was required to repay the money, together with interest as calculated in terms of the Exchequer and Audit Act No. 66 of 1975. If any other error was made in calculating the subsidy, the land user was obliged to repay the money (paid in error) within 60 days. Failure to pay within a period of 60 days, would result in interest being levied in accordance with the latter Act. A tariff list approved by the then Minister of Agriculture and Water Supply served as the basis for calculating the amount of subsidy due, in terms of the flood relief scheme. Different tariff lists may be approved in future for other flood disaster areas.

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CHAPTER 11: GROUNDWATER IN NATAL/KWAZULU

The vital importance of groundwater in rural areas...

Windpomp

jare lank was sy geteem
'n stem in die woestyn
maar toe skielik sluk hy wind
oor die werfdans en krulle van 'n kind

en vurig en fier soos oor 'n kleintandooi
die kop geolie en die stert bloedrooi
staan ons ou slyttand met 'n nuwe rug
oor die jongste boorgat opgerig

die dun bene bewe
die binnegoed kry lewe
dit slurp en dit skrok
dis bokjol dis amok

en toe met pype wat roggel
en koggel
met geknars en gekraak in lit
en gebit

toe raak die gulpwater ryp
in die weggooipyp
roesrooi en vol wind
klopdisselkind klopdisselkind

ons windpomp pomp weer water
en hoe later hoe kwater
ons windpomp pomp weer water
en wie wie't gesê hy's bokkapater

L. Strydom, quoted in Opperman, D.J., 1979. Senior Verseboek, Tafelberg-uitgewers Bpk, Cape Town, 278 p.

Die oue put

Ginds op 'n knoppie ver geleë,
weg van die woel'ge werf en weë,
armoedig lê en skaars beskut
in middagslaap die oue put.

* * *

Sy hoor naby en altyd nader
die skapies om haar heen vergader;
sy open mild haar waterfles
om al wat kom die dors to les.

Dit put maar en sy gee maar immer,
dit put maar en sy weier nimmer;
net soos 'n moeder, so opreg,
gee sy haar laaste druppel weg!

Totius (J.D. Du Toit), quoted in Malherbe, D.F., 1959. Afrikaanse Verse: 'n Bloemlesing vir die Middelbare Skool, Nasionale Boekhandel Bpk, Cape Town, 214 p.

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11.1 *Introduction*

This chapter contains information on the groundwater resources of Natal/KwaZulu. Groundwater in the province (with very few exceptions), has not received much attention in the scientific and planning literature - in view of the generally high rainfall. Much of the literature on groundwater in Natal/KwaZulu is scattered amongst various sources and is uncollated. Some of the information is also out of date. A further complicating factor is the geological terminology used in the various reports, which does not reflect the latest stratigraphic classification system (see the chapter on geology).

Dr R. Maud of Durban kindly provided a concise overview of some pertinent aspects of groundwater hydrology in Natal/KwaZulu (Sections 11.6 - 11.8, but excluding Table K2). A detailed survey of the groundwater resources of South Africa undertaken inter alia by the Department of Water Affairs and Forestry is currently being finalized. The analysis will provide important information (not only for Natal/KwaZulu). The data accordingly, will be incorporated in any second edition of the source book*. Some emphasis in this chapter, has been placed on small groundwater systems (boreholes, wells and springs) which are used in black rural settlements in particular. Groundwater resources are of paramount importance in these areas, in order to meet the day-to-day needs of a significant proportion of the South African population. The present chapter also contains information of relevance to the study of sanitation and solid waste management (see the appropriate chapters, elsewhere in this publication).

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* A set of 11 reports (released after this chapter was written), is available for Natal/KwaZulu. See Section 11.17.2.

11.2 Groundwater in South Africa*

Some 105 towns and villages in South Africa are virtually entirely dependent on groundwater for all requirements. Numerous other towns use both surface and groundwater (known as the conjunctive use of water)**. In Natal/KwaZulu, areas such as Ubombo, Magudu, Pomeroy and Creighton are largely dependent on groundwater resources. On a country-wide basis, groundwater consumption accounted for approximately 15% or some 1 800 x $10^6 m^3$ of the total water consumed in 1980 (excluding the environment). Groundwater use in South Africa may possibly grow (within the next 20 - 30 years), to about 5 000 x $10^6 m^3 y^{-1}$, depending on the economics of irrigation and increases in urban demand. While groundwater use is often regarded as a rural phenomenon, it is interesting to note the effect of droughts in the urban areas, where in 1983/84 for instance, the urban consumption from private boreholes may have been of the order of 40 x $10^6 m^3$. Private (yard) boreholes are especially popular in the Pretoria-Witwatersrand-Vereeniging area (Vegter, 1984).

An analysis of groundwater consumption in South Africa in 1980, revealed that urban use (including industries and mines supplied from public sources), amounted to 73 x $10^6 m^3$ or 4,1%, with urban consumption from private boreholes amounting to 10 x $10^6 m^3$ or 0,6%. Rural domestic use accounted for 120 x $10^6 m^3$ or 6,7%. Stock watering consumed approximately 100 x $10^6 m^3$, with the major demand being for irrigation (1 400 x $10^6 m^3$ or 77,8%). (Only some 1,7% of the total groundwater-irrigated area in South Africa in 1976 was in Natal, although irrigation using groundwater is a growing trend in the province). The total volume of groundwater used by mines and quarries in South Africa was estimated at 100 x $10^6 m^3$ (Vegter, 1984). Various estimates of the overall

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* Discussion based on Vegter, J.R., 1984. The role of ground water in South Africa's water supply, Proceedings of the International Conference on Ground Water Technology, National Water Well Association and the Borehole Water Association of Southern Africa, 14 - 17 November 1984, Johannesburg, p. 3 - 14., as well as Anonymous, 1986. Management of the Surface Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages. A brief non-technical overview of groundwater for domestic (urban) consumption is the following: Anonymous, 1993. An alternative source of water supply, SA Waterbulletin, VOL 19(2), p. 22 - 23.

** This figure was subsequently revised, and it is now estimated that approximately 280 towns and smaller settlements are fully or partly reliant on groundwater. See Kok, T.S. and Simonis, J.J., 1989. Notes on the geohydrological characteristics of the more important water bearing formations of South Africa, with special reference to possible groundwater pollution, Technical Report No. Gh 3641, Directorate of Geohydrology, Department of Water Affairs, Pretoria, 13 p. + app.

groundwater consumption in Natal/KwaZulu are provided in the chapter on the surface water resources of Natal/KwaZulu, elsewhere in this publication.

Over 90% of South Africa's groundwater occurs in limited volumes in numerous small secondary aquifers, specifically in the near-surface fractured and weathered part of hard rock formations of igneous, metamorphic and sedimentary origin*. Secondary aquifers are used mainly on farms for domestic needs, for stock watering and for small scale irrigation. Villages and small to medium sized towns can also be supplied from suitable secondary aquifers. Larger volumes of groundwater are only found in a few geological formations with a relatively small areal distribution. These sources are the extensively leached (karstified) dolomitic strata of the southern and western Transvaal as well as the northern Cape; the (primary) geologically young coastal sand deposits, and alluvium along some rivers. The popular misconception that all groundwater exists as "underground rivers and streams" is only true in a few dolomitic and limestone areas.

Yields from boreholes in South Africa can be classified according to their potential use. Boreholes with a low yield ($<1\ \ell\ s^{-1}$) should be used for gardening as well as for domestic and stock purposes. Medium yield boreholes ($1 - 5\ \ell\ s^{-1}$) have a similar use, while high yield boreholes ($5 - 20\ \ell\ s^{-1}$) can supply small villages and towns. Very high yield boreholes ($>20\ \ell\ s^{-1}$) are suitable for large scale irrigation and urban requirements. It should be borne in mind that in many parts of South Africa, typical borehole yields average less than $2\ \ell\ s^{-1}$ (Vegter, 1984).

The exploitation potential of groundwater is determined by the volume of water held underground, the recharge rate, and losses through seepage to springs, wetlands, streams, lakes, "estuaries", and the sea. Also important are evapotranspiration losses. Groundwater use is likewise constrained by practicality and economics. In secondary aquifers, low borehole yields effectively prevent exploitation of the resource for bulk water supplies. Limited demand and associated costs may also not justify the maximum exploitation of groundwater. In certain areas of the Karoo for example, groundwater

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* A useful glossary of South African groundwater terms can be found in the following: Parsons, R., 1995. A South African aquifer system management classification, WRC Report No. KV 77/95, Water Research Commission, Pretoria, 20 p. + app. Any comprehensive textbook on groundwater may likewise be consulted. See also: Pfannkuch, H-O., 1990. Elsevier's Dictionary of Environmental Hydrogeology: in English, French and German, revised edition, Elsevier, Amsterdam, 332 p.

resources are unlikely to be fully developed, given the limited water demand (mainly agriculture) and hence the costs of exploiting the resource (Anonymous, 1986).

The maximum volumes of water which can be abstracted from aquifers on a continuous basis is dependent on recharge. Across South Africa, the annual (rainfall) infiltration to groundwater has been estimated at 16 000 - 37 000 x $10^6 m^3$ (Anonymous, 1986). Only a portion of this recharge can be abstracted (on the basis of dependable yield), since groundwater losses through seepage and evapotranspiration cannot be recovered by boreholes or wells. It is difficult to quantify volumes which could be abstracted on an economic basis from aquifers, although a figure of 5 400 x $10^6 m^3 y^{-1}$ for South Africa as a whole, has been suggested. It is likely therefore, that groundwater will eventually constitute not much more than 15% of the supply from conventional sources. Within such limitations, groundwater potential may be exploited in several ways. Firstly, as a renewable resource abstracted continuously at a more or less constant daily rate (for example, an urban water system) and secondly, as a non-renewable resource (where recharge is nil or inadequate) which is "mined" until the stored volume is exhausted*. A third option involves a combination of the first two methods, while a fourth option concerns use as a renewable resource, although abstracted at high rates for short periods, in order to supplement surface sources during peak periods or in an emergency. With the exception of certain surveyed areas, there is a considerable lack of knowledge of groundwater potential and use in South Africa, which currently precludes greater exploitation of the resource on a wider scale. The designation of groundwater as private water (see below) is a further inhibiting factor (Anonymous, 1986).

An important consumer of groundwater (seldom commented upon), is the environment. Four types of ecosystems are influenced by groundwater: firstly, dune vegetation with a phreatic component (plants using groundwater rather than soil-water derived from rain); secondly, wetland vegetation; thirdly, "estuaries" and finally, surf-zones. Both water quality and the water table depth are important parameters in terms of wetland and dune vegetation, as well as surf-zone microalgal communities. Groundwater is a valuable source of freshwater for estuaries, inter alia to contain salinity levels (Campbell, Parker-Nance and

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* It is interesting to note that mines and quarries in South Africa, pumped approximately 405 x $10^6 m^3$ of water from workings in 1980. It is not clear how much of the water was intercepted rainwater, seepage resulting from mining activities or groundwater per se. No definitive data are available on the extent to which this water was used, prior to disposal (Anonymous, 1986).

Bate, 1992)*. The use of water by the environment has not been fully recognized in South Africa, and this is especially true for groundwater.

11.3 A brief overview of certain legal aspects of groundwater in South Africa**

In terms of Section 5(1) of the Water Act No. 54 of 1956, the land owner has a right to the use of water including groundwater, occurring on his land. This water is legally regarded as private water (see the section on Some legal aspects of water in South Africa in the chapter on the surface water resources of Natal/KwaZulu). In terms of Section 5(2) of the Act however, private water (including groundwater) which does not have the potential for common use, cannot be sold for use on any other land or be conveyed for own use beyond the boundaries of the land on which the water is found, without a permit. Excluded from this permit requirement is water which is transferred for own domestic or stock watering purposes, or which is used in accordance with consent in terms of the Conservation of Agricultural Resources Act No. 43 of 1983.

In order to prevent over-exploitation of groundwater which can be commonly used, the Minister of Water Affairs and Forestry may declare an area to be a subterranean water control area (in terms of Section 28 of the Water Act). These areas can include a dolomite area, an artesian area, or any area where the groundwater resources are rapidly diminishing due to over-exploitation. The drilling of boreholes and the abstraction of groundwater in subterranean water control areas is placed under the control of the Minister, in order to regulate development and utilization (Sections 29 - 33 of the Water Act). The Minister makes allocations based on the total estimated groundwater resources of the area, as well as the priority requirements of the existing property owners and other users. Subterranean water control boards may be established in terms of the Act, if desired by the residents. In certain circumstances, such as severe drought or over-exploitation of the groundwater, the Minister is empowered to further restrict the abstraction of groundwater in

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* See Campbell, E.E., Parker-Nance, T. and Bate, G.C., 1992. A compilation of information on the magnitude, nature and importance of coastal aquifers in southern Africa, WRC Report No. 370/1/92, Water Research Commission, Pretoria, 192 p.

** Discussion based on Anonymous, [1990]. Groundwater: guidelines for boreholes, Borehole Water Association of Southern Africa, the Division of Earth, Marine and Atmospheric Science and Technology of the CSIR, the Department of Agricultural Development, the Department of Water Affairs and the Geological Society of South Africa, Pretoria, 29 p. A more detailed discussion can be found in Visser, F., 1987. Ground-water law in South Africa, Tydskrif vir Hedendaagse Romeins-Hollandse Reg, VOL 50(4), p. 412 - 427.

subterranean water control areas. There are 13 control areas in South Africa covering some 5 000 km^2. No subterranean water control areas are found in Natal/KwaZulu.

The use of water abstracted from a mine (for dewatering purposes) is subject to permit restrictions in terms of Section 12 of the Water Act. Compensation by the mine owner to those adversely affected by the abstraction can be made a permit condition in terms of Section 12B of the Act. The prevention of pollution of any water (including groundwater) through farming operations is controlled in terms of Section 23A of the Act. The Minister (by virtue of Section 12C of the Act), may require that data from any borehole drilled for private purposes in a gazetted area, be supplied to the Department of Water Affairs and Forestry. Groundwater surveys and drilling performed on behalf of the Department can be undertaken on private property in terms of Section 166 of the Act - provided that reasonable notice is given to the owner or occupier of the land.

11.4 Some primary sources of groundwater information for Natal/KwaZulu

11.4.1 Detailed surveys

Very few large (regional) groundwater studies have been undertaken in Natal/KwaZulu. Two major regional (as opposed to sub-regional) surveys were those reported by Van Wyk (1963) and Anonymous (1971)*. Several important sub-regional studies have been undertaken for example, by the CSIR and the University of Zululand in the Richards Bay-St Lucia area, as well as further north (see the bibliographic database).

No detailed province-wide analysis of groundwater in Natal/KwaZulu has yet been undertaken. An overview has however, been provided by Maud (see later in the chapter). A major groundwater study is currently underway in Natal/KwaZulu involving the Directorate of Geohydrology of the Department of Water Affairs and Forestry, Private Bag

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* See Van Wyk, W.L., 1963. Ground-water studies in northern Natal, Zululand and surrounding areas, Memoir No. 52, Geological Survey, Department of Mines, Pretoria, 135 p. and map, as well as Anonymous, 1971. Report on a survey of the natural resources of Natal South Coast (European owned land), supplement to the maps: undertaken for the Town and Regional Planning Commission, Pietermaritzburg, 1971, Report No. TS 57/69, R.F. Loxton Hunting and Associates, Johannesburg, 110 p. + app. and 10 maps. The firm also undertook a survey of Maputaland in 1969/1970 involving inter alia groundwater resources. (See (i) the relevant maps discussed in the chapter on maps, elsewhere in this publication and (ii) the bibliographic database). See also, James, A.G. and Fuller, H.L.M., 1987. Register of southern African hydrological data sources, South African Water Information Centre, CSIR, Pretoria, 287 p.

X313, Pretoria, 0001; as well as the Joint Services Boards, Mhlatuze and Umgeni Water; the KwaZulu Government; the Natal Provincial Administration; the Natal Parks Board; the Department of Agriculture, and the Water Research Commission. The Geographic Information System (GIS) of the Department of Water Affairs and Forestry is being used in the survey. The Natal/KwaZulu study forms part of a nation-wide assessment of groundwater resources.

The Directorate of Geohydrology, Department of Water Affairs and Forestry, Private Bag X9052, Cape Town, 8000, initiated a project to derive groundwater data - including water quality information - for selected primary aquifers along the South African coastline. The data (where relevant), will be entered in the National Groundwater Database (discussed below). The aquifers examined in Natal/KwaZulu were in the environs of Richards Bay - Lake Mzingazi, Lake St Lucia and Lake Sibaya. Various computer mapping procedures illustrating the data are available, together with a numeric database which contains information on each aquifer studied (Campbell, Parker-Nance and Bate, 1992 - above)*.

11.4.2 Groundwater data

There are four main (historical) sources of groundwater data for Natal/KwaZulu. Data generated by the (former) Department of Development Aid in (former) South African Development Trust (SADT) areas and to some extent in KwaZulu, can be found in the National Groundwater Database. Similarly, data provided by the KwaZulu Water Development Fund - established by the South African Sugar Association - are also available in the National Groundwater Database. The Fund began operations in KwaZulu during 1980. The 1982/83 drought resulted in a major drilling programme, with a large number of boreholes drilled in KwaZulu (and to a very limited extent in SADT areas), under the auspices of the Fund. All the boreholes were equipped with handpumps.

A large groundwater data-set is held by the KwaZulu Department of Agriculture and Forestry. The data include boreholes drilled under the auspices of the KwaZulu Department of Works. Such data are likewise available in the National Groundwater

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* Separate maps for part of St Lucia can be obtained from the Natal Town and Regional Planning Commission, Private Bag X9038, Pietermaritzburg, 3200. The seven map sheets entitled, Water table (Eastern Shores of Lake St Lucia), with a scale of 1 : 20 000, were published in 1978. One map at a scale of 1 : 20 000, also published in 1978, concerns Sodwana Bay and is entitled, Water table (Sodwana Bay). The latter map is also available from the Commission.

Database. The data-sets include borehole location (co-ordinates and place name); the thickness and type of strata intersected; the depth at which water was found; the depth to which the water rises (water-rest level); yield and the type of pump fitted, if known.

Two consulting engineering firms appointed by the KwaZulu Department of Agriculture and Forestry, namely, Drennan Maud and Partners, P O Box 30464, Mayville, 4058, and Davies Lynn and Partners, P O Box 2328, Durban, 4000, have compiled groundwater resource data-sets for some districts in KwaZulu (see the bibliographic database). The data concern boreholes and springs, pumps, taps on pipelines, dams and cattle dips. The data have been plotted on 1 : 10 000 scale orthophoto maps. It should be noted that 1 : 50 000 scale transparent overlay maps showing the geographic location of most of the boreholes drilled in KwaZulu since the mid-1970s, have been compiled by the KwaZulu Department of Agriculture and Forestry. The data include information supplied by the two consulting engineering firms.

Chemical and/or bacteriological water quality data (where applicable) for boreholes drilled inter alia by the KwaZulu Department of Agriculture and Forestry, the KwaZulu Department of Works, and the KwaZulu Water Development Fund are available at the CSIR Division of Water Technology regional laboratory, P O Box 17001, Congella, 4013, and at the CSIR Isipingo regional laboratory. (The bulk of the KwaZulu Agriculture and Forestry/Works data are available at the Isipingo laboratory). Groundwater chemical and bacteriological analysis is also undertaken by Mhlatuze Water, P O Box 1264, Richards Bay, 3900, on behalf of the KwaZulu Department of Agriculture and Forestry and the Zululand Joint Services Board (in the north eastern areas of KwaZulu). The data will be incorporated in the current Natal/KwaZulu groundwater survey (see above). Both yield and water quality data (where applicable) provided by other organizations such as the Geological Survey of the Department of Mineral and Energy Affairs; the Natal Parks Board; the Joint Services Boards; irrigation boards; the (South African) Department of Agriculture, and the (Natal) Development and Services Board will likewise be included in the groundwater survey of the province*.

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* See Hobbs, P.J., 1993. Department of Water Affairs and Forestry Directorate: Geohydrology: Natal/KwaZulu hydrogeological mapping project - results of Phases 1 and 2, final report, November 1993, Groundwater Consulting Services, Johannesburg, various pages + app. See also, Lynch, S.D., Reynders, A.G. and Schulze, R.E., 1994. Preparing input data for a national-scale groundwater vulnerability map of southern Africa, Water SA, VOL 20(3), p. 239 - 246., as well as Parsons, R. and Tredoux, G., 1995. Monitoring groundwater quality in South Africa: development of a national strategy, Water SA, VOL 21(2), p. 113 - 116.

Incidental groundwater data (mainly quality), will in future be available from the Department of Water Affairs and Forestry. The data refer to permitted landfill sites where the routine testing of groundwater is now required in terms of the Environment Conservation Act No. 73 of 1989 (see the chapter on solid waste management). Certain aspects of groundwater quality monitoring are discussed in the chapter on water quality. Some health implications of water in general, are outlined in the chapter on health.

11.4.3 The National Groundwater Database

The database is operated by the Directorate of Geohydrology of the Department of Water Affairs and Forestry in Pretoria. The database has been developed in association with the Institute for Groundwater Studies, University of the Orange Free State, P O Box 339, Bloemfontein, 9300, and forms part of the Hydrological Information System (HIS). (See the section on Sources of hydrological data in the chapter on the surface water resources of Natal/KwaZulu). More than 200 different parameters per site, can be stored in 32 data-sets in the National Groundwater Database. The data-sets include locational data (in terms of 1 : 50 000 scale topographic maps); geological/aquifer data; site construction and installation data; discharge rate/water level information; meter reading data; pumping test data, and water quality data. Groundwater resources information available from the database concerns boreholes, wells, springs, sinkholes, tunnels, shafts or drains and seepage ponds. Data may be abstracted at various scales ranging from individual (specific) sites to all sites with a particular farm number, or within given co-ordinates, a district, a drainage region or a province. Various statistical and mapping procedures can be undertaken (Cogho, Kirchner and Morris, 1989)*.

All the chemical and bacteriological as well as indicator species data are stored in a separate database (the Water Quality Database also maintained by the Department of Water Affairs and Forestry - see the chapter on water quality). The key link between the National Groundwater Database and the Water Quality Database is the specific H-number allocated to <u>each</u> groundwater quality sample. If regular sampling is to be undertaken at

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* See Cogho, V.E., Kirchner, J. and Morris, J.W., 1989. A National Ground-water Data Base for South Africa - development of the data base, WRC Report No. 150/1/89, Water Research Commission, Pretoria, 276 p., as well as Cogho, V.E., Kirchner, J. and Morris, J.W., 1989. A National Ground-water Data Base for South Africa - user's guide, WRC Report No. 150/2/89, Water Research Commission, Pretoria, various pages. See also, Kirchner, J., Morris, J.W. and Cogho, V.E., 1987. Development of a National Ground-water Data Base, <u>Water SA</u>, VOL 13(3), p. 165 - 170.

a particular site, then a station number must be allocated to that site. Most groundwater sites however are infrequently sampled, while some sites are sampled only once. Groundwater data can be obtained from the Directorate of Geohydrology in Pretoria. The National Groundwater Database can be accessed via the Computing Centre for Water Research, University of Natal, Private Bag X01, Scottsville, 3209, and the Institute for Groundwater Studies.

It should be noted that a requirement laid down by the Borehole Water Association of Southern Africa, P O Box 2178, Southdale, 2135, is that all drilling contractors (who are members of the Association), must record borehole/well data on standard forms provided by the Association. The information should then be submitted to the Directorate of Geohydrology for possible inclusion in the National Groundwater Database. Unfortunately, drillers who are not members of the Association seldom bother to send the relevant data to the Directorate. Borehole logs (of varying degrees of accuracy), are rarely kept for long periods by these drillers.

11.5 Groundwater models

Groundwater models are not discussed in this publication (as stated in Chapter 1). Nearly all such modelling has been undertaken in the drier areas of South Africa*. The chapter on solid waste management contains a brief description of some computer techniques applicable to landfill sites in South Africa, with reference to groundwater contamination.

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* See for example, Van Tonder, G.J. and Cogho, V.E., 1987. AQUAMOD: 'n twee-dimensionele Galerkin eindige element simulasieprogram vir mikrorekenaars vir die voorspelling van versadigde grondwatervloei en besoedeling, Water SA, VOL 13(3), p. 175 - 180., as well as Verwey, J.P. and Botha, J.F., 1992. A comparative study of two - and three - dimensional groundwater models, VOL 1, WRC Report No. 271/1/92, Water Research Commission, Pretoria, 97 p. Some groundwater models used in South Africa, as well as other groundwater models, are briefly described in the following: CSIR Environmental Services, 1995. Procedures to assess effluent discharge impacts, WRC Report No. TT 64/94, Water Research Commission and the Department of Water Affairs and Forestry, Pretoria, 352 p. See in addition: Bredenkamp, D.B., Botha, L.J., Van Tonder, G.J. and Janse van Rensburg, H., 1995. Manual on quantitative estimation of groundwater recharge and aquifer storativity: based on practical hydro-logical methods, WRC Report No. TT 73/95, Water Research Commission, Pretoria, 363 p. + app.

11.6 A review of groundwater conditions in Natal/KwaZulu*

11.6.1 Types of aquifers

Both primary (porous flow) and secondary (fracture flow) aquifers are found. In the former, the groundwater is contained in voids between the material particles, while in the latter it is contained in discontinuities such as joints, fractures and bedding planes, within and between various types of hard rock. Existing groundwater exploitation in Natal/KwaZulu, and its potential exploitation, mainly involves secondary aquifers. Primary aquifers consisting of unconsolidated sediments are not common in the province. These aquifers comprise sandy sediments in the "estuaries" of major rivers, the sandy beds of rivers themselves in places, and sandy sediments of the Maputaland area of the Zululand Coastal Plain where shallow perched water table conditions are evident (due to the presence of underlying less permeable sediments)**.

11.6.2 Factors affecting groundwater availability

Apart from aquifer type, a number of other factors influence the availability and characteristics of groundwater at any locality in Natal/KwaZulu. The most important of these are rainfall and topography and to a lesser extent, type of vegetation cover. Rainfall over the region varies from about 1 400 - 2 000 mm annually in the elevated, and parts of the coastal areas, to about 320 - 600 mm in the Dry Interior (River) Basins and in the northern Lowveld areas. Most of the rain falls in the summer months when evapotranspiration is high. There is no linear relationship between rainfall and the yield and occurrence of groundwater in a given geological formation. However, the amount and distribution of rainfall is very important in that the recharge of groundwater results therefrom, and this has a marked effect on the sustainable exploitation of groundwater (and the occurrence of springs). The recharge of groundwater results from percolation to deeper levels both of rain falling on the soil surface, and percolation directly from the beds

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* Section written by Maud, R.R., 1993. Drennan Maud and Partners, Durban, with editorial amendments by Alcock, P.G., 1994.

** See Section 11.12.1.

of streams and rivers when they contain water. Van Wyk (1963)* from studies in the northern drier parts of Natal/KwaZulu, found that groundwater recharge as a percentage of mean annual rainfall varied from zero to nearly 20% - the actual amount averaging about 10%. It follows that the recharge of groundwater and thus its general overall availability will be higher and better in wetter parts of the province, rather than where drier conditions prevail, all other factors being equal. To some extent, deeper and more clayey soil cover can reduce the amount of recharge that would otherwise occur in areas of high rainfall. However in the latter instance, there is usually less need to exploit groundwater than in the drier areas. The amount of rainfall can also have a very marked effect on the quality of the groundwater. Thus, saline groundwater is frequently encountered in areas of low rainfall, this seldom being the case in high rainfall areas.

Topography has an important influence on groundwater in two ways. Firstly, steepness of the ground slope (although the soil cover might be thin - facilitating deep percolation), increases runoff and thus decreases potential recharge. Secondly, beneath elevated areas, the depth to the water table is greater than in the more low-lying areas, this being particularly marked on high ground adjacent to pronounced escarpments. As indicated above, the thickness and nature of the soil cover can have an important influence on the recharge situation. In general, the deeper the soil cover above the underlying weathered and unweathered rock, the less rainfall penetrates through the soil column; and the more clayey the soil, the more impermeable it is, with surface runoff on slopes (where applicable) increasing accordingly.

The type of vegetation at any locality is mainly a function of the prevailing rainfall, where conditions have not been modified by human activities, for instance, by crop cultivation or the establishment of plantations. The amount of soil moisture utilized by vegetation in transpiration can greatly influence the amount of rainfall which ultimately becomes groundwater recharge by (a) its effect on the moisture content of the soil prior to rainfall, which affects runoff (antecedent soil moisture), and (b) by its effect on runoff conditions as a result of the cover afforded to the soil surface. Deep rooted plantations of exotic trees can have a marked impact on groundwater recharge, by contrast with the natural vegetation (usually grassland) which formerly prevailed - runoff also increasing on the bare

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* See Van Wyk, W.L., 1963. Ground-water studies in northern Natal, Zululand and surrounding areas, Memoir No. 52, Geological Survey, Department of Mines, Pretoria, 135 p. and map.

ground beneath gum and wattle trees for example (although pine trees do build up a good ground cover of pine needles with time).

11.6.3 Hydrogeological characteristics of geological formations and methods of groundwater extraction

(a) Primary aquifers

(i) Alluvial and estuarine sediments (Quaternary)

- **Aquifer characteristics**

Sandy sediments of alluvial and estuarine origin of Quaternary age can be an important source of groundwater, especially if the rivers concerned drain an area of mainly granitic geology which yields a coarse (Umgeni type) sand - as is evident in many of the coast and coastal hinterland rivers of Natal/KwaZulu. Whereas the depth of sediment above the underlying bedrock is limited to a maximum of about 6 - 8 m in river courses inland of the "estuaries" (this depth of sediment occurring in basins of softer rock between shallower buried bars of hard rock), in the estuaries themselves, the depth of sediment can be as much as 50 m in the case of major rivers. As the shoreline is approached however, the incidence of impermeable silt and clay horizons generally increases in the profile, to the extent that no exploitable aquifers may be present in these localities, the quality of the groundwater also deteriorating progressively as the number of clayey horizons increases, and the shoreline is approached.

- **Shallow well points**

Groundwater contained in the shallow sandy aquifers beneath and adjoining river beds can be exploited by well point systems. The maximum depth to which these can operate satisfactorily is about 6 m, due to the water being extracted by means of vacuum pumps. Well points can be installed by jetting or hammering. Individual well points are normally spaced about 5 - 6 m apart. Yields from 50 mm diameter individual well points are usually in the range 1 - 2 $m^3\ h^{-1}$ in suitably coarse sandy alluvium. Water quality is generally good, with a total dissolved solids or salts (TDS)* content of up to about 500 mg ℓ^{-1}, which is much the same as the surface water in the river channel. For their continued satisfactory performance, well points generally need to be back-washed every 6 - 12 months. The installation of shallow well points in river beds was frequently resorted to as an emergency source of water, when many of the rivers in Natal/KwaZulu virtually dried up during the severe drought years of 1982/83 and again in 1992/93. Shallow well point systems currently serve as a source of domestic and industrial water on the Buffalo and Nondweni rivers in the interior of the province, and on the Matigulu, Nonoti, Mdloti, Lovu, Mpambanyoni, Mtwalume and Imbizana rivers in the coastal zone.

- <u>Deep screen wells</u>

Deep screen wells have been installed in several of the upper estuarine reaches of rivers in Natal/KwaZulu, where alluvial and estuarine sediment depth is considerable. The depth of screen wells, from which water is obtained by means of a pump situated in a sump beneath the screen, varies in the approximate range of 15 - 30 m. Potential screen well sites must be subjected to a preliminary test boring investigation, in order to ensure the accurate location of the screen in the sandy aquifer - given that impermeable silt and clay horizons are frequently also present - and to optimize screen opening size in terms of the particle size distribution of the sand. Yields from (20 - 25 m deep), 200 - 300 mm diameter screen wells vary in the range of 60 - 180 m^3 h^{-1}. Groundwater from screen wells generally has a higher iron content (due to the chemically reducing conditions prevailing at the abstraction depth in the aquifer), than is the case for groundwater derived from shallower depths down to about 5 - 6 m. An iron content of up to about 40 mg ℓ^{-1} is frequently encountered in the deeper groundwater. The iron is readily removed by aeration and storage. If located too close to the shoreline of the "estuary" (within a distance of about 2 km therefrom), the chloride content of the deeper groundwater is often somewhat marked. If screen wells are sited within a distance of about 1 km from the shoreline, sea water intrusion becomes a possibility with continuous long term extraction. Generally, the quality of the groundwater obtained from deep screen wells in alluvial and estuarine sediments is good to moderate, with TDS values usually in the range of 400 - 1 200 mg ℓ^{-1}. Deep screen wells have been installed as a source of urban

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* The terms "total dissolved solids" and "total dissolved salts" are both used in the scientific literature.

residential, industrial and irrigation water on the Mfolozi, Mhlatuze, Mvoti, Mgeni and Mpambanyoni rivers in the coastal zone.

(ii) Berea Formation (Quaternary)

In the immediate coastal areas the base of the unconsolidated sandy Berea Formation of Quaternary age, which is an in situ weathered coastal dune, can frequently be an aquifer of considerable significance. Groundwater moves in a downslope or seaward direction in the base of the formation (perched on the surface of the underlying impermeable bedrock), in a 1 - 2 m thick zone, the highly permeable overlying sandy material of considerable thickness being dry. Where it emerges at the toe of the slope, the groundwater is often under some slight artesian pressure - this being the origin of Currie's Fountain adjoining the Botanical Gardens at the foot of the Berea in Durban*. Shallow screen wells of about 10 - 15 m depth installed in this sandy aquifer provide good yields of the order of 20 m^3 h^{-1} from 200 mm diameter wells, the water quality being very good. The aquifer in the same situation at the base of the Berea Formation, on the south bank of the Mhlatuze River on the ridge opposite Felixton, is also being successfully exploited for domestic water by means of a number of 20 - 25 m deep screen well boreholes. The groundwater quality is very good in view of the exceptionally high mean annual rainfall of approximately 1 500 mm.

Interestingly in Durban, one deep screen well borehole of some 70 m depth located on the highest part of the Bluff ridge of the Berea Formation, provides a good yield of high quality groundwater on the basal contact of the formation with the underlying calcareous sandstone (aeolianite) of the Bluff Formation. This groundwater constitutes seawards seepage from the Happy Valley interdune swamp between the Bluff and Wentworth ridges, to the west of the Bluff ridge proper.

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* Currie's Fountain was the second source of water for the growing infant city until about the 1870s. The original water supply in Durban came from shallow wells dug in the alluvial sediments, as at the Old Fort, and at the present location of Old Well Court between Smith and West streets - just west of Field Street in the Central Business District.

(iii) Holocene sands (Quaternary)

Along the eastern margin of the Zululand Coastal Plain (mainly in Maputaland), but also extending further south into the Richards Bay area, shallow groundwater perched in the base of the young Holocene age cover sands (on the impermeable surface of the underlying more clayey Port Durnford Formation)*, is exploited using shallow wells up to 4 - 6 m deep. This is only possible where the thickness of the cover sands does not exceed such a depth, and where the mean annual rainfall is in excess of approximately 800 mm.

The shallow wells generally consist of simple open pits, but deeper wells, as drilled by the KwaZulu Department of Agriculture and Forestry, are lined with concrete rings and are covered with a concrete slab. On some of these improved wells, windmills or solar pumps have been installed, for example, where the well is the water supply for a clinic or transport depot. Usually however, the water is hand-bailed from the base of the well as a source of domestic water. Although water quality is very good (with a TDS content often less than about 600 mg ℓ^{-1}), the yields of these wells are generally not large, due to the relatively low transmissivity of the fine sand comprising the aquifer. Yields from such wells seldom exceed about 1 m^3 h^{-1}. As shown by the drilling of numerous unsuccessful deep boreholes into the underlying Quaternary Port Durnford Formation, which extends to a depth of about 30 m, and below into the deeper underlying Cretaceous St Lucia Formation, little, if any possibility exists of obtaining larger groundwater supplies from greater depths. The siltstones of the gently seaward dipping St Lucia Formation and older Cretaceous formations which underlie the Zululand Coastal Plain to a very considerable depth - the thickness of which increases in a seaward direction to some 2 500 m at the coastline - are extremely poor aquifers. The limited groundwater which may be present in these rocks of marine origin is usually highly saline.

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* The perching of the water table on the impermeable lower member of the Port Durnford Formation is exploited in the extensive dredge pond mining of heavy minerals present in the overlying cover sands, as undertaken in the Richards Bay area.

(b) Secondary aquifers

(i) Intrusive rocks

A summary of the more important geological formations and the rock types thereof, which as secondary (hard rock) aquifers, comprise by far the greater portion of Natal/KwaZulu is given in Table K1. Intrusions of Karoo dolerite occur extensively in the province, especially in the interior. These commonly take the form of sub-horizontal or slightly inclined sheets or sills, which may vary in thickness from about a metre to more than 100 m. Due to their resistance to erosion, the thicker dolerite sheets in the interior of Natal/KwaZulu result in high-rising prominent flat-topped topographic features, which characterize much of the interior of the province. With ascent in the sediments of the Karoo Supergroup, the incidence and magnitude of the dolerite sheet intrusions increases markedly. In rocks below the Karoo Supergroup, except in some places in the sandstones of the Natal Group, intrusions of Karoo dolerite are relatively rare. Vertical or inclined dyke intrusions of Karoo dolerite, which seldom exceed about 6 m in width, are also generally rare in the province, by comparison with the incidence of sheet intrusions. Dykes tend to be somewhat more common in the upper portions of the Karoo Supergroup. Adjacent to the dolerite sheets, especially the thinner sheets, and also in the case of the dykes, the country rocks are often disturbed for a distance of a few metres. The Karoo dolerite sheets (and where they occur), the dykes of the same material, are of major significance for groundwater in Natal/KwaZulu.

- **Geological structure**

The coast and coastal hinterland areas generally for a distance of up to some 80 km from the sea are strongly faulted, which is indicative of the rifted margin of the sub-continent at that point. The distribution of the faults reflects a conjugate shear fracture pattern resulting from tensional conditions prevailing during the disruption of Gondwana, which initiated the coastline in the late Jurassic (160 million years ago). The faults are all of the tensional or gravity type, the fault surfaces dipping towards the downthrow side at steep angles of about 80°. The structure of this part of Natal/KwaZulu is mainly one of tilted

Table K1: **Some geological formations in South Africa, with special reference to Natal/KwaZulu.**

Stratigraphy		Geological formation	Lithology
Quaternary Pleistocene	Maputaland Group	Sibayi Formation (Berea Formation) (Bluff Formation) Port Durnford Formation	Calcareous and other sediments
Tertiary Miocene		Uloa Formation	Sandstone and sands Calcareous sandstone Shelly coquina
Cretaceous		St Lucia Formation Msinene Formation Makatini Formation	Siltstones Limestones Conglomerates
Jurassic	Lebombo Group	(Intrusive)	Dolerite
		Jozini Formation	Rhyolite and dacite
		Letaba Formation	Basalt
		Drakensberg Formation	Basalt
		Clarens Formation	Sandstones
		Elliot Formation	Mudstones
Karoo Supergroup		Molteno Formation	Sandstones
Triassic	Beaufort Group		
	Tarkastad Subgroup	Various formations	Mudstones, shales and sandstones
	Adelaide Subgroup	Various formations	Mudstones, shales and sandstones

Table K1: Some geological formations in South Africa, with special reference to Natal/KwaZulu (continued).

Stratigraphy		Geological formation	Lithology
Karoo Supergroup (continued)	Ecca Group	Normandien Formation (Estcourt Formation)	Mudstones and shales
		Volksrust Formation	Mudstones and shales
Permian		Vryheid Formation	Sandstones and shales
		Pietermaritzburg Shale Formation	Shales
Carboniferous	Dwyka Group	Dwyka Tillite Formation	Tillites/diamictites, conglomerates, sandstones, siltstones and mudstones
Cape Supergroup Devonian	Witteberg Group	Msikaba Formation	Sandstones
Ordovician-Siluraian	Natal Group	Mariannhill Formation Durban Formation	Sandstones, quartzites, shales and conglomerates
Mokolian Vaalian Randian Swazian	Various groups, metamorphic suites and complexes (Mapumulo, Mzimkulu, Ngoye, Tugela, Mfongozi, Nsuzi, Mozaan and Nondweni)	Various formations	Granites, gneisses, schists and amphibolites

<u>Source</u>: Maud, R.R., 1995. Unpublished document, Drennan Maud and Partners, Durban.

<u>Note</u>:

(i) Descending order in the above table implies increasing geological age.

(ii) The term "Dwyka Tillite" <u>per se</u> is no longer in common use in the geological literature. The term "Karoo" appears in older texts as "Karroo". The latter spelling has been discontinued. Brackets denote a pending change in nomenclature.

fault-bounded blocks, although horst and graben (block and basin) structures are present in the northern central part of this area. In the north, the structure of the Lebombo area is mainly that of a seaward faulted flexure. The tilted fault blocks in general are tilted in a seaward direction, the amount of tilt of the individual blocks usually increasing in this direction to a maximum of about 15°. Locally however, blocks can tilt in an inland direction, as in the major block north of Port Shepstone and between the Thukela and Mlalazi rivers. Fault zones may vary in width from less than a metre in the case of small faults, to 10 m and more in respect of large faults such as the Eteza Fault north of Empangeni. Fault zones may comprise either silicified or kaolinised fault breccia.

The interior of the province by contrast, is unfaulted, the rocks of the Karoo Supergroup generally having a regional bedding dip of less than about 3° in a westerly or inland direction. The rocks of the Proterozoic and Archaeozoic basement - recently renamed - beneath the sediments of the Natal Group and the Karoo Supergroup, where exposed, are usually strongly lineated, and are steeply foliated in rock types other than batholithic granite intrusions. All rocks in the region are jointed (a discontinuity on which no significant movement has taken place), to a greater or lesser degree.

Faults and joints being sites of weakness in the rocks, tend to be erosion-susceptible and thus very frequently have rivers and streams aligned along them. In some parts of the province, the drainage pattern is fully controlled by the distribution of faults and joints. Faults and joints have a very important effect on the groundwater situation (as discussed later). In the tilted fault block coastal area, the inclination of the bedding planes of sedimentary rocks where so tilted (particularly sandstones), has a marked influence on the movement of groundwater, as the direction of such movement is generally in the down-dip direction of the bedding planes.

- **Distribution of geological formations**

Away from the faulted coast and coastal hinterland areas of Natal/KwaZulu - where different rock types are very frequently juxtaposed as a result of the faulting - increases in altitude result in a simple elevation in the lithostratigraphic sequence. Overall, the granitic Proterozoic and older rocks form a fairly broad belt on the inner margin of the coastal faulted zone. These rocks occur at the coast in the south but at an increasing distance from the coast in a northerly direction, except where they are returned to this location by major faults as in the environs of Empangeni. The areas underlain by granitic rocks can be at high elevations on the interfluves between rivers, and much lower in the river valleys and basins.

On either side of this granitic belt in the centre and south of the province there is usually a somewhat elevated zone of Natal Group sandstone, which, to the east in the faulted coastal margin, becomes mixed with areas of the Dwyka Tillite Formation, the Pietermaritzburg Shale Formation and the Vryheid Formation - these formations in general occurring in this sequence in a seaward direction; the Vryheid Formation not being found to any significant extent south of Durban. To the west, the Dwyka Tillite Formation constitutes a relatively narrow zone, in places particularly to the north, if resting directly on granitic rocks without the intervention of the Natal Group sandstone. Sequentially and altitudinally to the west, the mudstones, shales and sandstones of the Pietermaritzburg Shale, Vryheid, Volksrust and Estcourt formations occur - further west these being overlain by the mudstones, shales and fine-grained sandstones of the various formations and subgroups of the Beaufort Group. Forming the highest part of the province on its central and south western boundary, is a narrow steep zone consisting of the Molteno, Elliot and Clarens formations, which are topped off by the thick pile of Drakensberg basalts. In the north east of Natal/KwaZulu, the Karoo Supergroup rocks are faulted and flexed down in the Lebombo structure, the equivalent of the Drakensberg Formation basalt here being the Letaba Formation basalt which underlies the erosional trough of the Lowveld. The overlying erosionally resistant rhyolite and dacite of the Jozini Formation forms the long linear elevated feature of the Lebombo Range to the east thereof, beyond which it underlies the Zululand Coastal Plain.

On the western margin of the Zululand Coastal Plain, Cretaceous marine sediments of the Makatini Formation are exposed, overlying the Jozini Formation rhyolite and dacite, this being successively overlain by the gently-dipping Msinene and St Lucia formations. These marine formations of Cretaceous age are covered by a veneer of unconsolidated Tertiary and Quaternary sediments of the Uloa, Bluff and Berea formations, as well as by the KwaMbonambi Formation - the latter being re-distributed cover sands of Holocene age. The distribution of all these formations on the coastal plain shows a marked north-south alignment parallel to the western margin of the plain, at the foot of the strongly linear Lebombo structural feature.

11.6.4 Aquifer characteristics of geological formations and faults

(a) Proterozoic and older granitic and related rock formations

In these rocks, moderate to good yields of groundwater of the order of 5 - 10 $m^3 h^{-1}$ are often obtained in lower rainfall areas, where such rocks occur in the Dry Interior (River) Basins of the province. Water quality is usually good with TDS values mostly less than 500 mg ℓ^{-1} for boreholes with good yields (in areas of moderate and higher rainfall). Due to their generally linearly well-foliated and jointed nature (and to a lesser extent the faulting therein), the most favourable sites for boreholes in these formations are on valley lines and intersections. In areas of more massive granite and gneiss, basins of weathering of the rock (which are good groundwater reservoirs), are frequently present on joint-controlled valley intersections. Many successful boreholes have been drilled on rocks of these formations in the south and centre of the province.

(b) Natal Group formations

The mainly sandstone rocks of the formations comprising this group are the best and most consistent secondary aquifers in Natal/KwaZulu. Groundwater in these formations is contained on bedding planes, and on joints and fractures therein. Yields from 150 mm diameter boreholes (80 - 100 m deep), are usually in the range 2 - 10 $m^3 h^{-1}$, although higher yields of 15 - 20 $m^3 h^{-1}$ are frequently encountered. Dry boreholes are rare. Water quality in boreholes drilled in formations of the Natal Group is generally very good, with TDS values often less than 500 mg ℓ^{-1} (much of this being temporary bicarbonate hardness). For the most part, sandstones of the Natal Group form topographically elevated areas which have a high rainfall. The best locations for boreholes are on joint or fault-related valley intersections or valley lines.

(c) Dwyka Tillite Formation

This formation is the poorest secondary aquifer in Natal/KwaZulu. However, reasonable yields are sometimes obtained in boreholes drilled in favourable locations. In general, it is only worthwhile drilling on faults and major joints (which are reasonably frequently present) in the formation. Within the formation itself, yields when obtained at all, are less than about 3 $m^3 h^{-1}$, the lowest yields being associated with the drier areas such as the interior valleys in the north. Water quality from boreholes in the formation is variable, although often of moderate quality with a TDS content of up to about 1 500 mg ℓ^{-1}. Poorer quality water is usually associated with low yielding boreholes in the drier areas, but very poor quality water has been obtained in some boreholes with a good yield, even in high rainfall areas. The most favourable places for boreholes in the formation are low-lying sites on faults and major joints, particularly in the coastal zone (where these are associated with deep weathering of the formation), as noted in some localities along the margin of the outcrop of the overlying unconsolidated Berea Formation.

(d) Pietermaritzburg Shale and Vryheid formations

In the shales of the Pietermaritzburg Shale Formation, as well as in the shales and sandstones of the Vryheid Formation (which also contain coal horizons), moderate yields of up to about 7 $m^3 h^{-1}$ are usually obtained from (80 - 100 m deep), 150 mm diameter boreholes drilled in the formations. Occasionally, higher yields of 10 $m^3 h^{-1}$ and more are obtained in the formation itself, although the better yields are often associated with intrusive sheets of Karoo dolerite within the formations. The groundwater quality in the formations is usually moderate to poor with TDS values of up to about 1 500 mg ℓ^{-1}. A characteristic of the groundwater occurring in shales of both formations - particularly those of the Pietermaritzburg Shale Formation - is the relatively high iron content which can be as much as 40 mg ℓ^{-1}. The higher iron content is usually found in boreholes with low yields. In the Vryheid Formation, good quality groundwater is not always associated with areas of high rainfall. Accordingly, in the Gingindlovu-Mtunzini area which has a mean annual rainfall of more than 1 000 mm, poor quality saline groundwater is frequently encountered in boreholes drilled in the formation. Favourable locations for the siting of boreholes in these formations are on valley intersections and valley lines, preferably where there is an indication that a Karoo dolerite intrusion is likely to be penetrated at depth in the borehole.

(e) Volksrust and Estcourt formations and various formations of the Adelaide and Tarkastad subgroups (Beaufort Group) and the Molteno, Elliot and Clarens formations

The rocks of these formations mainly comprise shales and mudstones with a lesser amount of fine grained sandstones intercalated therein, especially in the Adelaide Subgroup. The Molteno and Clarens formations consist primarily of sandstones, the former medium to coarse and the latter, fine and massive. These rocks are very frequently intruded by sheets of Karoo dolerite of varying thickness from a metre or so to 100 m and more. Intrusive dykes of the same rock type are also moderately common, particularly with increasing elevation in the Beaufort Group. Yields of groundwater in the rocks of these formations tend to be low, in the range 1 - 5 $m^3 h^{-1}$ mainly in the drier areas, although higher yields are obtained in association with intrusions of Karoo dolerite. Along the foot of the Drakensberg Escarpment in the west, the Molteno, Elliot and Clarens formations form a narrow steep zone in which, in general, groundwater possibilities are very limited - particularly in the massive sandstone of the Clarens Formation and in the shales and mudstones of the Elliot Formation. The groundwater potential is somewhat better in the jointed sandstones of the Molteno Formation. These same rocks, except for the Molteno Formation which is virtually absent, also occur in the north east of Natal/KwaZulu on the western side of the Lebombo structure. Here the Beaufort Group is represented by the much thinner Emakwezini Formation, while the Elliot Formation is represented by the Nyoka Formation. The Clarens Formation retains its name. In this low rainfall area the groundwater potential of these formations is very limited and what groundwater is present, is mostly of very poor quality and is very saline. The most favourable location for boreholes in the formations (other than on intrusive Karoo dolerite features therein), are on joint-controlled valley intersections and valley lines.

(f) <u>Drakensberg, Letaba and Jozini formations</u>

The basalts of the Drakensberg Formation only occur on the very high ground forming the Great Escarpment, along the south western boundary of Natal/KwaZulu. In this situation there is little likelihood of the formation ever being exploited as a source of groundwater. Some distance away from the drawdown effects of the escarpment face however, the potential for groundwater of good quality in the well-bedded and jointed basalt is often good.

In the north east of the province, forming the main part of the Lebombo structure, is the linear north-south Lowveld area underlain by the Letaba Formation basalts, and to the east of it, is the elevated Lebombo Range itself, which is underlain by the erosionally resistant rhyolite and dacite of the Jozini Formation. Van Wyk (1963 - above) working in northern Natal/KwaZulu observed that it is sometimes possible, in basins of decomposition in the basalt, to obtain yields of the order of 3 - 5 $m^3 h^{-1}$, while boreholes intersecting zones of decomposition in the hard rock (to a depth of 80 - 100 m) generally yield 1 - 5 $m^3 h^{-1}$. Towards the western base of the Lebombo Range, numerous north-south trending dykes are present in the basalt. Boreholes drilled on these dykes give somewhat better yields. In this area of relatively low rainfall, groundwater quality in the basalt is usually poor with a TDS value of 750 - 2 500 mg ℓ^{-1}. Boreholes drilled in the rhyolite and dacite of the Lebombo Range itself often have a low yield of the order of 1 - 3 $m^3 h^{-1}$. Such rocks also contain several north-south trending dolerite dykes, the drilling of boreholes on which (especially where they cross valleys), can give rise to yields of 5 $m^3 h^{-1}$ or more in places. Groundwater quality in the more elevated (higher rainfall) western part of the Lebombo Range is relatively good with a TDS content of 600 - 1 200 mg ℓ^{-1}. However, on the drier, lower eastern slopes of the Range, the water quality deteriorates and saline waters with a TDS content of 750 - 2 000 mg ℓ^{-1} predominate.

(g) Intrusive Karoo dolerite

Intrusions of Karoo dolerite, in the form of sheets or sills and dykes, occur in all the hard rock geological formations in the province (as described above). Supplies of groundwater are normally associated with the contacts of these features with the country rock into which they have been intruded. In the case of sheets or sills, higher volumes of groundwater are usually associated with the basal contact of the intrusion, rather than with its upper contact - the generally well-jointed nature of the dolerite facilitating groundwater movement therein. For this reason, springs and seepage lines often occur where the lower contacts of dolerite sheets (particularly the thicker ones), have been exposed on the valley sides by erosion. Due to disturbance and fracturing of the enclosing rock, enhanced groundwater movement frequently takes place in the country rock immediately adjoining the intrusion. This situation also obtains in the case of linear, vertical or steeply inclined dykes of Karoo dolerite, groundwater movement being enhanced by the general close-jointing of the dolerite itself, and by the frequently fractured nature of the immediately adjoining enclosing rock. Accordingly, in the case of dykes, groundwater can be found both within the dyke itself as well as on its margins. In general, the latter situation results in greater flows of groundwater in boreholes, than is the case in the dyke itself. Particularly good yields of groundwater are obtained from boreholes drilled on or in dolerite dykes, where these features cross, or are aligned along valley lines.

The yields of boreholes drilled on or into dolerite intrusions are variable, although they can be as much as 10 $m^3 h^{-1}$ or more in some instances. The quality of groundwater obtained from boreholes drilled into intrusions of Karoo dolerite is generally good. Quality however, can be markedly influenced by the characteristics of the groundwater present in the enclosing rock formation, particularly where borehole yields are low. The quality of groundwater in dolerite often reflects the prevailing rainfall conditions, with waters with a low TDS content of 300 - 750 mg ℓ^{-1} found in high rainfall areas. A higher TDS content in the range 750 - 1 500 mg ℓ^{-1} is evident in areas of relatively low rainfall.

(h) Faults

The numerous faults of Jurassic age which characterize the hard rock geological formations of the coast and coastal hinterland, are often very good sources of groundwater. Boreholes must usually intersect thin inclined zones of fault breccia at some depth below ground level for good yields to be obtained, although in the case of broad fault zones, boreholes drilled wholly within the fault zone breccia also frequently provide very good yields of groundwater (contained within the secondary cemented fragmented fault breccia, which may be either or both silicified and kaolinised). In the case of the normally very poor yielding Dwyka Tillite Formation, virtually the only locations on which boreholes can be drilled with a reasonable chance of success, are on fault zones within or bounding the formation.

While occasionally on thin fault zones, dry holes may be encountered on drilling, more frequently, yields of up to 40 - 50 $m^3 h^{-1}$ can be obtained in boreholes drilled on or into fault zones. Given the large yields usually associated with fault zones, the quality of the groundwater is normally good, with a TDS value of the order of 700 mg ℓ^{-1} or less. Thin fault zones in areas of low rainfall however, in which relatively low yields are obtained, can provide poor quality water - reflecting the nature of the groundwater in the enclosing rock.

(i) Makatini, Msinene and St Lucia formations (Cretaceous)

The aquifer characteristics of these soft rock sediments (which comprise a basal conglomerate of the Makatini Formation and overlying siltstones of the formation plus the other overlying formations), are very poor. These formations are effectively limited to the Zululand Coastal Plain in the north east, where for the most part, they occur under a relatively thin veneer of younger unconsolidated sediments. The siltstones of the sediments are poorly bedded and widely but weakly jointed, with no significant structures therein such as faults, folds, etc. Accordingly, little, if any groundwater and no crude oil or gas (which has been drilled for in these formations both on-shore and off-shore), has been found. Where groundwater is encountered in such formations, it is usually highly saline with a TDS content of the order of 5 000 mg ℓ^{-1} and more.

(j) Uloa Formation (Miocene)

This thin shelly and sandy limestone formation overlies the Cretaceous sediments, and underlies the virtually impermeable Port Durnford Formation, in places on the Zululand Coastal Plain. Due to the presence of solution cavities (where found), the formation is a very good aquifer (effectively a primary aquifer), with yields in the range of 5 - 10 $m^3 h^{-1}$ being derived from the few boreholes that have intersected the formation. Water quality in this aquifer is usually good with a TDS content normally less than about 750 mg ℓ^{-1}.

(k) Port Durnford Formation (Pleistocene)

This unconsolidated formation which underlies much of the Zululand Coastal Plain at shallow depths - on account of the clayiness of its lower member - is virtually impermeable and thus carries no groundwater. Due to the impermeability of the lower member, a water table is normally located in the lower portion of the sandy upper member of the formation, or in the sands of the surface KwaMbonambi Formation, which also overlies the Port Durnford Formation in many parts of the coastal plain (the perched groundwater in these sands occurring in a primary aquifer as considered above).

In essence, the study and location of groundwater in South Africa generally, is highly complex and there are seldom "firm guarantees" that groundwater in the required volumes or possibly quality can be abstracted at any specific site. A brief overview of the groundwater potential of Natal/KwaZulu with reference to bioclimatic group (see the chapter on catchments) is provided in Table K2.

Table K2: A brief overview of the groundwater potential of Natal/KwaZulu in terms of bioclimatic group.

Bioclimatic group	Description
1	Groundwater is present at shallow depths in the Recent sands, although yields are mostly limited
2	Dolerite dykes and Ecca Series as well as Dwyka Series rocks are likely to provide mediocre to fair supplies, with numerous springs in certain areas. Boreholes with yields greater than 2 273 - 3 410 ℓ h^{-1} are rare
3	Dolerite dykes and Ecca Series as well as Dwyka Series rocks are likely to provide mediocre to fair supplies, with numerous springs in certain areas. Boreholes with yields of 2 273 - 4 546 ℓ h^{-1} are rare
4	Boreholes commonly yield less than 4 546 ℓ h^{-1}. Boreholes with higher yields might be successful in the vicinity of dolerite dykes
6	Boreholes with yields greater than 1 364 - 4 546 ℓ h^{-1} are rare. Dolerite dykes and Ecca Series rocks should provide limited supplies
8	Boreholes with yields greater than 1 364 - 2 273 ℓ h^{-1} are rare. Dolerite dykes and Ecca Series rocks might provide mediocre supplies
10	Limited supplies are obtainable at shallow depths in the sands of certain rivers. Boreholes with yields greater than 1 364 - 2 273 ℓ h^{-1} are rare

Source: After Phillips, J., 1973. The agricultural and related development of the Tugela Basin and its influent surrounds: a study in subtropical Africa, Natal Town and Regional Planning Commission Report, VOL 19, Pietermaritzburg, 229 p. and maps.

Note:

(i) No data are presented for bioclimatic groups 5, 7, 9 and 11.

(ii) The table provides a broad perspective only, for readers requiring an overview in terms of bioclimatic group. The information is somewhat dated and sparse.

(iii) The geological terminology used above refers to the publication in question. The source of the latest terminology is discussed in the chapter on geology.

11.7 Methods of groundwater exploitation*

The groundwater contained in hard rock secondary aquifers in Natal/KwaZulu is exploited by means of boreholes which are normally drilled by pneumatic rotary percussion methods. The depth of the boreholes varies from 40 - 120 m, with an average depth of about 80 m. The normal borehole diameter is approximately 150 mm, with variable lengths (3 - 8 m) of steel casing being required to support soil and weathered rock in the uppermost parts of the boreholes. In some high yielding boreholes in weak fault breccia, the sides of the boreholes have to be supported against collapse, either by the use of slotted steel casing, or well screens inserted in the boreholes.

11.7.1 Borehole depths

Groundwater occurs at shallower depths in topographically lower situations (such as valleys), by comparison with more elevated terrain. In lower-lying areas, borehole depths are generally of the order of 40 - 50 m, whereas in more elevated surroundings, boreholes are commonly some 100 - 120 m deep. Water-rest levels in boreholes are often above the depth at which groundwater is intersected therein. This characteristic is frequently made use of in deep boreholes in the rural areas of KwaZulu, where it is possible by means of handpumps installed on the boreholes, to lift groundwater from a maximum depth of about 50 m. It should be noted that in rural KwaZulu, a borehole yield of 100 - 200 $\ell\ h^{-1}$ (which elsewhere might be regarded as a dry borehole on drilling), is entirely acceptable as a source of domestic water.

11.7.2 Springs

Artesian groundwater conditions in Natal/KwaZulu are relatively rare, and where encountered, are nearly always associated with a borehole in a topographically depressed zone, below a very marked elevated area from whence the groundwater is derived. This situation also frequently applies at the few major cold and thermal springs in the province. An important cold water spring (used in part, for the water supply of Kokstad), is the Crystal Spring located just to the north of the town. Notable thermal springs in the

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* Sections 11.7 and 11.8 were written by Maud, R.R., 1993. Drennan Maud and Partners, Durban, with editorial amendments by Alcock, P.G., 1994.

province are the Shu-shu Spring in the bed of the Tugela River below Kranskop, the Lilani Spring in the Upper Mvoti Valley south of Kranskop, and the Natal Spa Spring on the Bivane River, south of Paulpietersburg.

Springs are numerous, particularly in the higher rainfall regions of the province, and in rural KwaZulu are an important source of water. The main disadvantage of springs is that yields are often seasonally variable. Secondly, springs (unless protected), are susceptible to contamination by livestock. Protection however, does not prevent subsurface pollution due to poorly sited pit latrines. Springs are most frequently associated with basal contacts of intrusive Karoo dolerite sheets, the margins of dolerite dykes, faults, major joints, and the bedding planes of sandstone rock - where these features intersect the ground surface below higher-lying areas (which act as the groundwater reservoirs to the springs).

11.8 <u>Methods of groundwater location</u>

Due to the prevailing topographic conditions (which give rise to shallow soil cover), the geology of Natal/KwaZulu is "visible", and borehole location can normally be undertaken in terms of directly observable geological characteristics. In some instances, geological field observations can be improved by the use of geological maps where these are available at a sufficiently detailed scale. Geological maps of virtually the entire province have been published at a scale of 1 : 250 000 (see the chapter on geology). Certain maps with a scale of 1 : 50 000 are likewise available.

Groundwater surveys are facilitated by the use of suitable single or stereoscopic air photos - from which features such as faults and dolerite dykes visible thereon - can be accurately located on the ground. Orthophotos can also be used. Less useful are satellite images, on which, because of their large scale, only broad features such as major faults and lineaments can be discerned, these features also being readily apparent on air photographs.

Where no specific local hydrogeological information can be gleaned, either from geological maps or direct on site observation, recourse can be made to a number of geophysical methods of investigation to establish likely hydrogeological conditions. These methods however, are expensive. Accordingly, those techniques which are rapid, are used in preference to more time consuming and hence more costly procedures. The various geophysical methods of hydrogeological investigation and their relevance in Natal/KwaZulu are briefly reviewed in Table K3. The next section provides information on some drilling programmes (mainly boreholes, but also wells), before spring protection in KwaZulu is discussed. The types of springs are then examined.

Table K3: Methods of hydrogeological investigation used in Natal/KwaZulu.

Method	Description
Electrical resistivity	The electrical resistivity method is based on variations in the passage of an electric current through rocks of different types. The method is particularly useful in locating groundwater-bearing shallow basins of decomposition above the unweathered rock. Since the water therein is the main conductor of electric current, its presence or absence is thereby revealed. The procedure indicates both vertical and horizontal conditions. This method of investigation is not presently used to any significant extent in Natal/KwaZulu
Electromagnetics	This method is similar to electrical resistivity and is based on the difference in electromagnetic conducting properties of various rock types. The method is increasingly being used in Natal/KwaZulu since it can be undertaken much more rapidly than electrical resistivity testing
Magnetics	The magnetics method utilizes the very small change in the normal magnetic field of the earth that is present (very locally), on concealed geological contacts, where rocks of very different types are contiguous (as in the case of intrusive dolerite dykes) - such contact zones frequently being the locations of preferential groundwater movement. This method has the advantage of speed, but is consequently often misused. The procedure is widely applied in Natal/KwaZulu
Gravity	The gravity method uses the differences in the local force of the earth's gravity (arising from the different densities of various rock types). Accordingly, contacts between differing rock types, which may be zones of preferential groundwater movement, can be determined. The method is not used to any great extent in Natal/KwaZulu
Seismic refraction	This method is based on differences in the rate of propagation of shock waves in rocks of various types, and in weathered rock materials and soils which overlie the rock. The procedure is most useful in indicating horizontal layering in the subsoil, and particularly the contacts between weathered and unweathered rock (with which groundwater occurrence may be associated). Seismic refraction is not presently used to any significant extent in groundwater surveys in Natal/KwaZulu, although it is in widespread use for earthworks and excavation investigations in a civil engineering context

Table K3: Methods of hydrogeological investigation used in Natal/KwaZulu (continued).

Method	Description
Divining	This exotically varied and unscientific parapsychological method of groundwater location is probably the most widely used procedure in Natal/KwaZulu, given its relative cheapness, speed, and the mystique associated with it. The information available (in terms of the reliability of the method) is strongly biased due to its mainly anecdotal nature, the successes of the method being trumpeted at the expense of its failures. Overall evidence indicates that divining is no more successful than any other method of groundwater location under comparable circumstances, and is frequently even less so. The successes of divining are dependent on the statistical probabilities that exist in respect of the differing groundwater conditions in various rock formations

<u>Source</u>: Maud, R.R., 1993. Unpublished document, Drennan Maud and Partners, Durban.

<u>See also</u>: (i) Botha, W.J. (ed), 1992. Evaluation of electromagnetic exploration techniques in groundwater exploration, WRC Report No. 212/1/92, Water Research Commission, Pretoria, 214 p. + app.

(ii) Meyer, R. and Coetsee, V. d A., 1991. Die toepassing van geoëlektriese metodes vir die bepaling van geohidrologiese veranderlikes, WRC Report No. 216/1/91, Water Research Commission, Pretoria, 55 p. + app.

<u>Note</u>: The Department of Water Affairs and Forestry has what might be termed "a water divining obstacle course" for the testing of water diviners confident enough to display their skills in a scientific context. No diviners have as yet, succeeded in "passing" the course with a suitably high success rate. Any such person achieving this honour, could command a fortune and would probably die a very rich man (Alcock, P.G., 1994).

11.9 Government drilling services

11.9.1 South Africa

The State drilling service is operated by the Directorate of Soil Conservation and Drilling Services, Chief Directorate: Agricultural Engineering and Water Supply, of the Department of Agriculture, Private Bag X515, Silverton, 0127. The Directorate mainly operates in difficult areas where private drillers are reluctant to work. Sixteen drilling inspectorates with 36 pneumatic drills and associated equipment are found in South Africa. The Natal

Region Drilling Inspectorate is based in Ladysmith (P O Box 299, Ladysmith, 3370) and serves Natal, parts of the Orange Free State and the Transvaal*. The primary aim of the drilling service is to improve natural grazing by assisting farmers to obtain borehole water for stock watering and domestic needs. The Directorate administers a rebate/subsidy scheme for drilling work undertaken by Government drilling teams, as well as by private drillers. Drilling for irrigation purposes is not subsidized, although such drilling can be undertaken (at the full tariff) when time permits. In view of the importance of the scheme, it is necessary to examine the relevant legislation in some detail.

With regard to Government Regulation Notice GN R3039/92 issued in terms of Section 2(d) of the Water Act No. 54 of 1956, the Minister of Agriculture - then Agricultural Development - may authorize the drilling of boreholes by a Departmental team (for which a rebate can be obtained). Various conditions apply, namely, that the property (a farm or smallholding) must not be situated within the water supply area of a local authority or other statutory body supplying water. The property must be at least 25 ha in extent, where the groundwater from the borehole is to be used solely for stock watering and/or domestic requirements. No drilling may be undertaken in a subterranean water control area, unless consent in terms of Section 30(2) of the Water Act has been obtained.

The basic tariff for drilling is fixed by the Minister and is published from time-to-time in the Republic of South Africa Government Gazette. The tariff includes a charge per metre drilled, as well as the costs of a pumping test to determine the yield of the borehole, plus the cost of any casing left in the borehole. No charge is made for any borehole (or non-recoverable casing), which was not properly completed or installed for technical reasons. The rebate paid to the land user by the Department depends on the depth (calculated to the nearest metre) and varies from 55% for the first 75 m, up to 75% for that part of the borehole deeper than 165 m. The cost of the casing is determined on a percentage basis with regard to the length of casing used. A rebate of 55% is allowed for the pumping test. The pumping test must be undertaken for nine hours, at an hourly tariff fixed by the Minister. The maximum rebate which may be claimed for boreholes drilled for stock watering purposes is R25 per Large Stock Unit, up to a total of R8 000 per property. The maximum rebate for boreholes drilled for domestic needs is R500 per property. Where

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* With effect from the 27th of April 1994, the Ladysmith office now operates in the geographic area of KwaZulu as well (for subsidy purposes). The Directorate prior to that date, was (and still is), involved in emergency drought relief drilling in KwaZulu.

boreholes are drilled for both stock and domestic purposes, the more advantageous rebate is applied. Special charges and conditions are enforced in specific circumstances, including a depth drilled of more than 250 m. Payment for charges incurred must be made in terms of cash deposited with the Department before or during drilling operations, or by means of a loan for drilling granted according to Section 10 of the Agricultural Credit Act No. 28 of 1966.

The quantity, type, quality and diameter of casing used in the borehole is at the discretion of the Department. No rebate is granted for casing left in an unsuccessful borehole at the request of the land user. An unsuccessful borehole is defined as a borehole yielding less than 125 $m\ell\ s^{-1}$ (unless special circumstances prevail). Land users are responsible for the provision of sufficient water of a suitable quality for the efficient operation of the Government drill, and for use by the drilling team. The land user is also responsible for the construction of an access road to the drilling site, any other road necessary to reach the boring camp, and for the initial clearing of the boring site and camping terrain. Failure to provide these services will result in extra costs.

Boring operations may be stopped if a suitable supply of water has been obtained in the borehole, or if there is a possibility of the drill or accessories being damaged or lost, or if satisfactory results from further drilling operations cannot be achieved. Other factors precluding further drilling are the costs of additional boring not being justified in terms of a possible sufficient increase in yield, and where a depth of 250 m is reached. Land users can apply for further drilling to be undertaken in these circumstances, which if agreed to, will be fully charged for. The maximum number of boreholes drilled is up to four per application, where the applicant is responsible for indicating the drilling sites (subject to Departmental approval). The Department may however, refuse to drill at a given site. If the applicant provides false or misleading information in terms of the rebate, then the rebate no longer applies and the applicant is liable for all costs.

By virtue of Government Regulation Notice GN R3040/92, also in terms of the Water Act, the Minister of Agriculture may authorize the payment of subsidies for the costs of drilling undertaken by private drilling contractors. The scheme is essentially the same as above, where no contract can be entered into with a private driller, prior to consent by the Department. The land user is required to indicate the drilling site (subject to various conditions). The borehole must be at least 15 m deep and 100 mm in diameter, and must comply with the requirements of the South African Bureau of Standards (SABS) Code of Practice No. 045-1974 for the testing of water boreholes (see Chapter 20). A continuous nine hour pumping test must be undertaken using suitable pumping equipment (not a bailer or an airblast). An unsuccessful borehole is regarded as one yielding less than 125 $m\ell\ s^{-1}$ (unless special circumstances prevail). No subsidy is payable by the Department unless receipts are submitted and the costs incurred are reasonable. Applicants are given one year in which to have the borehole drilled (after acceptance of the proposal by the Department), although the completion period may be extended for a further year (on application). The subsidy is calculated on the same basis as the above scheme, with the same maximum. The Department accepts no liability for the contract between the land user and the driller, makes no payment to the drilling contractor, and is not a party to any dispute. If the applicant provides misleading or false information to the Department, then the subsidy lapses and the land user is required to return the subsidy to the Department.

With regard to Government Regulation Notice GN R3041/92 issued in terms of Section 164 read with Section 162 of the Water Act, the Minister of Agriculture may provide a subsidy for additional works in respect of boreholes for stock watering and domestic needs. Additional works refer to appliances, pipelines, reservoirs and drinking troughs. The R6 000 per borehole subsidy (covering the costs of the actual construction of the additional works) is subject to the basic conditions outlined above, where the borehole is at least 15 m deep and 100 mm in diameter, and complies with the requirements of SABS Code of Practice No. 045-1974. The works must be completed within 12 months of consent, although an extension of a further 12 months may be granted. No subsidy is payable until receipts have been submitted, or if the applicant made use of second hand materials for any component of the additional works. If false or misleading information is provided by the applicant, then the applicant is required to return the subsidy to the Department.

11.9.2 KwaZulu

(a) Boreholes

Some 260 boreholes a year (10 boreholes per KwaZulu district), are drilled under the auspices of the KwaZulu Department of Agriculture and Forestry, Private Bag X05, Ulundi,

3838. The boreholes are for potable purposes (Alcock, 1989)*. A few boreholes are drilled for irrigation requirements only. Boreholes for potable needs are funded entirely by the KwaZulu Government and no financial contribution is requested from residents. It is not necessary for residents to provide any self-help labour. Boreholes for potable purposes are also drilled under the auspices of the KwaZulu Department of Works in certain high density areas, and at Government buildings such as police stations and clinics in rural areas. Successful boreholes are regarded as those yielding more than 600 ℓ h^{-1} in terms of a pumping test. Most boreholes are equipped with handpumps. A few boreholes (such as those at police stations and clinics) are fitted with windmills, solar powered pumps or diesel/petrol engines. The borehole drilling programme undertaken by the two KwaZulu departments began in 1972. The procedure involved is discussed in the chapter on the surface water resources of Natal/KwaZulu (see the section on Local authorities and services in KwaZulu). The Port Natal/Ebhodwe, the Natal Midlands, the Southern Natal, the Thukela and the Zululand Joint Services Boards have all been active in the drilling of boreholes for domestic (drought relief) purposes in black rural areas. The Directorate of Soil Conservation and Drilling Services (of the South African Department of Agriculture), and the Directorate of Geohydrology (of the Department of Water Affairs and Forestry), are involved in a joint drought relief drilling project in seven KwaZulu districts.

(b) Wells

Three organizations have mainly been involved with the sinking of wells in KwaZulu (Alcock, 1987)**. The KwaZulu Department of Agriculture and Forestry has installed numerous ring wells fitted with handpumps, in the northern sandy coastal plain of Maputaland, as well as in the Ogwini and Mpandleni agricultural regions of KwaZulu. Some self-help labour is required during installation. The Department is responsible for the maintenance of the wells and handpumps. All materials and equipment for installation as well as maintenance purposes are supplied by the Department.

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* See Alcock, P.G., 1989. Water supply systems for the Ximba Ward of KwaZulu: a proposed strategy, Occasional Publication No. 9, Department of Crop Science, University of Natal, Pietermaritzburg, 128 p. (It should be noted that as of June 1993, the KwaZulu Department of Works has been responsible for the emergency (drought relief) drilling of boreholes at Ulundi and Nongoma).

** See Alcock, P.G., 1987. Domestic water supplies in non-urban KwaZulu: existing water systems, Occasional Publication No. 8, Department of Crop Science, University of Natal, Pietermaritzburg, 100 p.

A programme initiated by the then Centre for Social Research and Documentation of the University of Zululand, involved the sinking of tube wells (primarily for domestic needs), as well as shallow ring wells mainly for the irrigation of communal gardens. Most of the wells have been sited in the coastal plain of Maputaland. Both types of wells have in situ bucket pumps and attached drainage pipes. Tube wells are generally 8 - 20 m deep, with ring wells 1 - 8 m deep. Well sinking is a co-operative venture with the individual customer paying for materials and installation time. The customer is also expected to provide unskilled labour. The Vonder drilling rig (imported from Zimbabwe), is owned by a local farmers' co-operative situated at KwaNgwanase.

The Rural Water Trust, P O Box 10823, Marine Parade, 4056, has concentrated on tube wells usually 4 - 12 m deep. The tube wells are fitted with handpumps and are often located near schools. The wells are usually installed together with 600 ℓ UV-resistant polyethylene storage tanks, where simple flocculation and chlorination processes are undertaken. Most of the tube wells have been sited in the northern coastal plain and areas further inland near Richards Bay; in the Valley Trust area, and in the environs of Adams Mission south of Durban. The Trust pays the costs, including installation, of all the equipment. Residents however, are expected to provide self-help labour during the installation process. The Trust also supplies the necessary chemicals, although in future, residents will be required to purchase their own chemicals. The staff of schools close to the tube wells are responsible for dosing the water.

11.10 Groundwater equipment

The Borehole Water Association of Southern Africa maintains a list of South African manufacturers or suppliers of numerous items of groundwater equipment, including drilling rigs and pumps. Several groundwater and geotechnical consulting firms, plus drilling and installation contractors are also listed. The list is periodically updated and is printed from time-to-time in the Borehole Water Journal, which is published by the Association. The Directorate of Soil Conservation and Drilling Services can also be approached for advice in terms of equipment and drilling contractors. The Groundwater Association of KwaZulu-Natal, P O Box 52042, Berea Road, 4007, is a further source of information.

11.11 Standards applicable to the borehole industry

The South African Bureau of Standards, Private Bag X191, Pretoria, 0001, has published certain codes of practice relating to the borehole industry (see Chapter 20). The Borehole Water Association of Southern Africa likewise, has a code of practice for borehole construction and pump installation*.

11.12 Spring protection in KwaZulu

Spring protection has been undertaken in KwaZulu since 1979, and is now an established procedure (Alcock and Lea, 1986)**. Storage reservoirs are usually reinforced concrete or ferro-cement. In its simplest form, protection involves excavation of the eye/s of the spring (to prevent contamination of open spring pools), and the building of a 0,5 m high V-shaped concrete spring protection chamber. A polyethylene outlet pipe is cemented in position through the chamber wall. Large rocks, graded stone, polyethylene sheeting and finally soil is used to backfill the chamber, leaving a sufficient discharge volume to ensure adequate drainage. The site should be grassed to prevent soil erosion and possible faecal contamination. The embankment above the eye is sometimes packed with a rock-mortar matrix to prevent soil collapse. An upslope diversion ditch lined with rocks (to direct overland flow away from the spring) is necessary on steep slopes, to avoid contamination of the chamber. No pit latrines, graves or livestock enclosures should be situated within 100 m upslope of springs used for potable purposes. Periodic maintenance of protected springs is confined to the removal of silt from the V-chamber, and the replacement of washers at reservoir standpipes.

Spring protection as undertaken by the KwaZulu Department of Agriculture and Forestry involves the self-help principle (Alcock, 1987 - above). The Department supplies crushed stone, building sand (if unavailable in the area), and reinforcing materials plus shuttering,

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* See Anonymous, 1987. Borehole Water Association of Southern Africa: minimum code of practice for borehole construction and pump installation, Borehole Water Association of Southern Africa, Johannesburg, 19 p. A popular (non-technical) guide for the layman is, Miller, P.M., undated. Know your own borehole, Borehole Water Association of Southern Africa, Johannesburg, 36 p. Advisory publications are also obtainable from the Groundwater Division, Geological Society of South Africa, P O Box 44283, Linden, 2104.

** See Alcock, P.G. and Lea, J.D., 1986. Springwater resources as a supply option in the peri-urban/rural Vulindlela District, KwaZulu, Occasional Publication No. 5, Department of Crop Science, University of Natal, Pietermaritzburg, 38 p.

as well as fittings and polyethylene piping (up to 500 m in length). The residents in turn, must provide the balance of materials, namely, building sand (if available in the area), all cement, and any additional piping and fittings (including taps) not supplied by the Department. Self-help labour for unskilled tasks such as trench digging is also needed. Semi-skilled personnel are provided by the Department. A concrete reservoir, often with a capacity of 3 150 ℓ or 5 510 ℓ is constructed if required by the residents. Spring protection undertaken by non-government organizations such as the Valley Trust, as well as by the Joint Services Boards and the Directorate of Community Development of the Community Services Branch, Natal Provincial Administration, essentially involves the same procedure as above, with residents responsible for most or all repairs to the spring protection chamber and reservoir. The demand for protected springs is greatest in the rural areas of KwaZulu. In peri-urban areas with some form of reticulated supply, protected springs are no longer used for potable requirements (except by the poorest of households or households at a considerable distance from the standpipes). Protected spring water in such circumstances is used for washing and general purposes.

11.12.1 Types of springs*

Springs can be divided into two broad categories namely, gravity springs and artesian springs. Both types of springs are further subdivided into depression or overflow springs. Since the geohydrology is complex, only a simplified discussion is presented here.

* Discussion based on Hofkes, E.H. (ed), 1983. Small Community Water Supplies: Technology of Small Water Supply Systems in Developing Countries, International Reference Centre for Community Water Supply and Sanitation and John Wiley and Sons, Chichester, 442 p. Lurie, J., 1989. South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering, Lexicon Publishers, Johannesburg, 342 p., provided a slightly different classification of springs, namely, stratum, valley, fault, artesian and tubular springs. Stratum springs are evident when downward percolating water in a permeable formation reaches an impervious layer. Stratum springs occur where the contact crops out. Valley springs form where the ground surface falls below the water table. Fault springs result when a permeable formation is brought against impermeable rocks by faulting. In an artesian spring, the water emerges under pressure due to entrapment in a geological formation. The water table is at a higher elevation than the outlet of the spring. Tubular springs occur in limestone and dolomitic areas where solution of the rock by water containing carbon dioxide, allows the groundwater to flow along bedding planes, fissures and joints enlarged by solution. Such water may emerge as springs. Where the openings consist of more or less rounded channels, they are known as tubular springs.

(a) <u>Gravity springs</u>

Gravity springs occur in unconfined aquifers*. Gravity depression springs are found where the ground surface dips below the water table. These springs have a limited discharge and are likely to be ephemeral. Gravity overflow springs fed <u>inter alia</u> by perched aquifers - a special type of unconfined aquifer - occur where the water is forced to the ground surface by an underlying impervious layer of clay or solid bedrock, or a change in bedrock type (geological contact). Perched aquifers are situated at some height above the main groundwater body**. Gravity overflow springs have a higher and less variable discharge than gravity depression springs, although the discharge may fluctuate with low flows in the dry season (Hofkes, 1983).

(b) <u>Artesian springs</u>

Artesian springs occur in confined or partly confined aquifers where an overlying and underlying impervious layer results in additional pressure, with the water unable to rise to its free (piezometric) level. Artesian depression springs are similar to gravity depression springs, although due to the pressure, the discharge is greater with less seasonal variation. Artesian fissure springs are a sub-category of artesian depression springs, where water issues from a fissure in the overlying impermeable layer. Artesian overflow springs, often with a considerable recharge area at some distance from the eye, have a high discharge (in view of the pressure) with little seasonal fluctuation. Artesian springs are less susceptible to latrine effluent contamination because of the overlying impervious layer. Secondly (as noted), the recharge area may be some distance away from the spring eye (Hofkes, 1983).

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* Readers are reminded that confined and unconfined aquifers are part of a single unified system, since all confined aquifers have an unconfined area where most groundwater recharge takes place. The water table in unconfined aquifers is at atmospheric pressure. The head at any place on the water table is simply the elevation of the water table. The top of the groundwater therefore, is the water table.

** Perched water tables in level terrain indicate that the underlying material transmits water more slowly than the rate at which the water enters the soil. Perched water tables in sloping land however, indicate that both the underlying and downslope materials (either because they are less permeable or because they are saturated), cannot transmit water at a rate which matches the rate of water influx.

Table K4 provides monthly discharge data for nine unprotected springs in the peri-urban/rural Vulindlela District of KwaZulu (Alcock and Lea, 1986 - below). Discharge of the springs reached a maximum in December or January, with a relatively steady decline thereafter at springs 6 and 8, for example. By contrast, somewhat rapid reductions in the discharge were observed at springs 1 and 9, with springs 2, 3 and 4 exhibiting a semi-uniform discharge pattern. Minimum discharge periods for all springs varied from March to September. The discharge pattern suggests that springs 2, 3 and 4 could be artesian in origin, in view of the generally high and sustained discharge throughout the survey period. Spring 9 can be classified as a gravity depression spring subject to a small and highly variable yield. The other springs are probably of the gravity overflow category, in terms of a less variable and higher discharge by comparison with gravity depression springs.

Springs in the study area are frequently found along the midslopes at nick-points (sudden changes in slope), often accompanied by a change in soil texture, with the more impervious clay having been deposited where the slope is flatter. Springs are also evident in minor hillslope valleys as well as at geological interfaces and outcrops, or along the footslopes of valley bottoms, and at the mouth of intersecting valleys. Multiple spring lines stacked vertically above each other are common where dolerite sills have intruded at several horizons in the stratigraphy. Relatively few springs are located near or on top of the crests of hills. Intrusive Karoo dolerite in the form of vertical or near vertical dykes and horizontal sills is found in large parts of the study area, with Ecca Group shale as well as sandstone also widespread. The intrusion of the dolerite has a marked effect on spring distribution, with an average of 18,5 springs km^{-2} observed in the study area. By contrast, the spring density in another part of KwaZulu (the Ximba Ward) which is underlain by deep granite of the Basement Complex, is 0,36 springs km^{-2} (Alcock, 1989 - above).

Table K4: Spring discharge in the Vulindlela District of KwaZulu, October 1982 - September 1983.

Month	Spring number									Total monthly discharge (m^3)	Mean monthly discharge (m^3)
	1	2	3	4	5	6	7	8	9		
	Monthly discharge (m^3)										
October	1 687,4	1 419,6	1 151,7	709,8	243,7	117,8	219,1	64,3	9,6	5 623,0	624,8
November	2 462,4	1 270,1	1 529,3	725,8	383,6	165,9	215,1	58,1	12,7	6 823,0	758,1
December	**8 437,0**	**3 348,0**	**2 008,8**	**1 017,8**	**428,5**	172,0	217,0	58,9	35,6	**15 723,6**	**1 747,1**
January	2 491,0	1 071,4	1 366,0	632,1	425,9	**375,0**	**219,6**	**107,1**	**160,7**	6 848,8	761,0
February	1 887,0	1 185,4	1 282,2	600,0	375,0	217,7	166,9	82,3	2,4	5 798,9	644,3
March	910,7	1 446,3	1 071,4	**455,3**	262,5	128,6	155,3	85,7	4,0	4 519,8	502,2
April	699,8	**544,3**	1 788,5	772,4	163,3	103,7	22,6	46,7	3,4	4 144,7	460,5
May	380,3	1 366,0	1 312,4	919,5	19,0	**53,6**	10,4	39,6	2,9	4 103,7	456,0
June	350,0	1 218,2	**699,8**	803,5	15,8	62,2	7,3	36,3	0	**3 193,1**	**355,0**
July	348,2	1 151,7	1 499,9	709,8	15,7	75,0	**2,7**	28,1	0	3 831,1	425,7
August	375,0	1 285,6	1 371,3	825,0	13,9	59,0	9,6	14,2	0	3 953,6	439,3
September	**311,0**	1 762,6	1 114,6	824,3	**13,0**	83,0	25,1	**10,4**	0	4 144,0	460,4
Total	20 339,8	17 069,2	16 195,9	8 995,3	2 359,9	1 613,5	1 270,7	631,7	231,3	68 707,3	7 634,4
Mean	1 695,0	1 422,4	1 349,7	749,6	196,7	134,5	105,9	52,6	19,3	5 725,7	636,2

Source: After Alcock, P.G. and Lea, J.D., 1986. Springwater resources as a supply option in the peri-urban/rural Vulindlela District, KwaZulu, Occasional Publication No. 5, Department of Crop Science, University of Natal, Pietermaritzburg, 38 p.

Note: (i) Maximum and minimum discharge is in bold.

(ii) A rough guide to the discharge rate in wetlands (vleis) (which are not suitable for human potable consumption due inter alia to contamination by livestock), is as follows. According to Hill, P.R., 1970. The reclamation, development, usage and management of vleis and other forms of wetland, In: Shone, F.K. (ed), Vleis of Natal: Proceedings of the Symposium held at Pietermaritzburg, South African Institute for Agricultural Extension (Natal Branch), 12 May 1970, Pietermaritzburg, p. 43 - 59., approximately 11,2 ℓ min^{-1} of water will be sufficient to maintain 1 ha of land in a permanently wet state in typical bioclimatic groups 3 and 4 areas, and on all but well drained soils.

11.13 Springs, boreholes and wells in Natal

Relevant data are presented on springs, boreholes and wells in Natal. Table K5 provides an indication of the number of springs on farms per magisterial district. Tables K6 and K7 outline depth and yield characteristics of boreholes and wells respectively. Both sets of data refer to 1960, given that no overall and up-to-date information is available. The present groundwater survey in Natal/KwaZulu (discussed earlier in the chapter) will address this problem - yielding current data and recent trends.

According to the 1959 - 1960 agricultural census, some 129 000 perennial and 48 000 ephemeral springs were evident on white, Indian or Coloured owned or managed farms in South Africa. Approximately 23% of all springs were in Natal*. No perennial springs were recorded on farms in the Ingwavuma, Mahlabatini and Ubombo magisterial districts, while most perennial springs were found in the Estcourt, Impendle and Utrecht magisterial districts.

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* Much depends on the definition of a "farm", as well as an "ephemeral spring". Readers should bear in mind that the boundaries of magisterial districts have been adjusted over the years. The names of certain districts have also changed. Some districts or components thereof subsequently became part of KwaZulu. East Griqualand was incorporated into Natal in 1976.

Table K5: The number of ephemeral and perennial springs on white, Indian or Coloured owned or managed farms in Natal, 1960.

Magisterial district	Number of springs		Total number of springs
	ephemeral springs	perennial springs	
Alfred	96	310	406
Babanango	173	631	804
Bergville	427	1 176	1 603
Camperdown	267	427	694
Dundee	701	1 374	2 075
Durban	18	7	25
Eshowe	167	291	458
Estcourt	957	2 360	3 317
Hlabisa	39	54	93
Impendle	465	2 124	2 589
Inanda	83	132	215
Ingwavuma	0	0	0
Ixopo	352	1 536	1 888
Klip River	817	1 800	2 617
Kranskop	116	281	397
Lions River	293	1 640	1 933
Lower Tugela	397	614	1 011
Lower Umfolozi	127	190	317
Mahlabatini	1	0	1
Msinga, Ndwedwe	6	19	25
Mtonjaneni	107	404	511
Mtunzini	92	147	239
Newcastle	1 121	1 825	2 946
New Hanover	259	1 033	1 292
Ngotshe	195	741	936
Nkandla	37	312	349
Nongoma	0	1	1
Nqutu	22	63	85
Paulpietersburg	244	794	1 038

Table K5: The number of ephemeral and perennial springs on white, Indian or Coloured owned or managed farms in Natal, 1960 (continued).

Magisterial district	Number of springs		Total number of springs
	ephemeral springs	perennial springs	
Pietermaritzburg	145	395	540
Pinetown	98	230	328
Polela	126	575	701
Port Shepstone	291	399	690
Richmond	332	1 043	1 375
Ubombo	9	0	9
Umvoti	325	1 206	1 531
Umzinto	273	704	977
Underberg	263	1 795	2 058
Utrecht	777	2 029	2 806
Vryheid	569	1 651	2 220
Weenen	120	216	336
Total	10 907	30 529	41 436
Mean number of springs per district	266,0	744,6	1 010,6
Range in springs for all districts	0 - 1 121	0 - 2 360	0 - 3 317
Overall spring density of farm area (km^{-2})	0,25	0,69	0,93

<u>Source</u>: After Anonymous, 1964. Report on agricultural and pastoral production 1959 - 60, South Africa and South West Africa: No. 4, agricultural machinery, implements, equipment and vehicles; fertilizers and soil dressings; irrigation and water supply; expenditure incurred in connection with farming operations; wages and salaries, Agricultural Census No. 34, Bureau of Statistics, Pretoria, 164 p.

<u>Note</u>: (i) The number of springs listed may constitute a considerable underestimate, since counts as far as can be determined, were based on farmers' responses and not on scientific water resources surveys. Nevertheless, spring numbers illustrate trends in the various districts indicative of rainfall, geology, topography and land use patterns. Based on the data and excluding black settled areas, Natal has the highest spring density of all the provinces.

(ii) The overall spring density figure is based on a Natal farm census surface area of 44 336 km^2 derived from the 1949 - 1950 agricultural census, and is consequently a first approximation.

(iii) The earlier agricultural survey (1949 - 1950) is discussed in the literature, with maps showing overall groundwater data for the four provinces. See Van Eeden, O.R., 1955. Die verbruik en aanvulling van ondergrondse water in die Unie van Suid-Afrika, Tydskrif vir Wetenskap en Kuns, Nuwe Reeks, VOL 15(2), p. 225 - 249.

Table K6: The depth and yield characteristics of functional boreholes providing usable water on white, Indian or Coloured owned or managed farms in Natal, 1960.

Item	Depth of boreholes (m)			
	<15,5	15,5 - 45,7	45,8 - 91,4	>91,4
Percentage of boreholes in each category	5,0	67,5	24,5	3,0
	Hourly yield (ℓ) of boreholes according to depth			
Percentage of boreholes in each category	<454,6	454,6 - 4 546,0	4 546,1 - 22 730,4	>22 730,4
<15,5 m	27,0	57,7	12,7	2,6
15,5 - 45,7 m	12,7	66,9	19,7	0,7
45,8 - 91,4 m	13,9	64,0	20,5	1,6
>91,4 m	15,8	67,6	15,8	0,8

Source: After Anonymous, 1964. Report on agricultural and pastoral production 1959 - 60, South Africa and South West Africa: No. 4, agricultural machinery, implements, equipment and vehicles; fertilizers and soil dressings; irrigation and water supply; expenditure incurred in connection with farming operations; wages and salaries, Agricultural Census No. 34, Bureau of Statistics, Pretoria, 164 p.

Note:

(i) The difference between a borehole and a well was not explained.

(ii) Boreholes were most numerous in the Estcourt, Utrecht, Dundee, Vryheid, Klip River, Lower Umfolozi and Newcastle magisterial districts. Dry boreholes were a feature of the Ubombo, Dundee, Hlabisa and Lower Umfolozi magisterial districts as well as five other districts. Water too saline to drink was a characteristic of some boreholes in the Lower Umfolozi Magisterial District.

(iii) Anonymous, 1991. Zululand Joint Services Board: potable water resources and distribution Phase 1 Report, December 1991, Report No. 1558/10, Watermeyer Legge Piesold and Uhlmann, Pietermaritzburg, 55 p. + app., in an overview analysis of certain borehole records held by the KwaZulu Department of Agriculture and Forestry and the Directorate of Geohydrology of the Department of Water Affairs and Forestry, found that mean borehole yield per district varied from 1 440 - 6 120 $\ell\ h^{-1}$. Maximum yield per district varied from 6 120 - 108 000 $\ell\ h^{-1}$. Of the 1 211 boreholes examined in the 19 Natal/KwaZulu magisterial districts, 362 boreholes or approximately 30% were regarded as dry (yielding less than 360 $\ell\ h^{-1}$). The boreholes assessed were those drilled since the early 1970s. Most KwaZulu boreholes are equipped with handpumps. Better yields are likely in some cases, if engine-driven pumps were to be fitted. Relatively high yields were noted in the Ngotshe, Vryheid, Eshowe and Nkandla magisterial districts.

Table K7: The depth and yield characteristics of functional wells providing usable water on white, Indian or Coloured owned or managed farms in Natal, 1960.

Item	Depth of wells (m)			
	<15,5	15,5 - 45,7	45,8 - 91,4	>91,4
Percentage of wells in each category	89,7	9,4	0,8	0,1
	Hourly yield (ℓ) of wells according to depth			
Percentage of wells in each category	<454,6	454,6 - 4 546,0	4 546,1 - 22 730,4	>22 730,4
<15,5 m	51,6	41,2	5,7	1,5
15,5 - 45,7 m	30,6	63,5	4,7	1,2
45,8 - 91,4 m	0	71,4	28,6	0
>91,4 m	0	100	0	0

Source: After Anonymous, 1964. Report on agricultural and pastoral production 1959 - 60, South Africa and South West Africa: No. 4, agricultural machinery, implements, equipment and vehicles; fertilizers and soil dressings; irrigation and water supply; expenditure incurred in connection with farming operations; wages and salaries, Agricultural Census No. 34, Bureau of Statistics, Pretoria, 164 p.

Note:

(i) The difference between a well and a borehole was not explained.

(ii) Wells providing usable water were most numerous in the Lower Tugela, Hlabisa, Port Shepstone and Estcourt magisterial districts.

(iii) Dry wells were a feature of the Pinetown and to a lesser extent the Dundee and Lower Tugela magisterial districts. Water too saline to drink was found on occasion in the Pinetown and Lower Tugela magisterial districts.

11.14 Overall groundwater quality in South Africa

Bond (1946)* classified the groundwaters of South Africa in terms of five groups, namely:

Group A: Highly mineralized chloride-sulphate waters
Group B: Slightly saline chloride waters
Group C: Temporary hard (carbonate) waters
Group D: Soda carbonate waters
Group E: Pure water group.

Some important characteristics of the various groups are outlined below:

Group A: Highly mineralized chloride-sulphate waters

(a) Waters usually contain 1 000 - 4 000 mg ℓ^{-1} total dissolved solids (TDS).

(b) SiO_2 expressed as a percentage of TDS is $<4\%$.

(c) High concentrations of chlorides are found in the range 27 - 51% of TDS.

(d) Relatively high sulphate concentrations are apparent, generally $>6\%$ SO_4 with up to 17% SO_4.

(e) Soda alkalinity ($Na_2CO_3/NaHCO_3$) is never present.

(f) The pH varies with a mean of 7,4.

(g) Total hardness is usually $<48\%$ (as $CaCO_3$), with permanent hardness generally $>12\%$.

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* Discussion based on Bond, G.W., 1946. A geochemical survey of the underground water supplies of the Union of South Africa with particular reference to their utilisation in power production and industry, Memoir No. 41, Geological Survey, Department of Mines, Pretoria, 216 p. (See also the chapter on water quality). Note: The unit of measurement for total dissolved solids used in older texts is mg kg^{-1} or parts per million (= mg ℓ^{-1}).

(h) Some of the waters, especially those arising in the Malmesbury and Cretaceous beds, approximate sea water in terms of given ionic concentrations.

Group B: Slightly saline chloride waters

(a) TDS values are in the range 300 - 350 mg ℓ^{-1}.

(b) With the further exception of a lower SO_4 content, there is little difference in percentage composition between the waters of Group A and Group B.

(c) Waters of the Table Mountain Series in Natal and in the Cape Province, and waters arising in the Witteberg quartzites in the Cape have been placed in Group E, although in terms of percentage composition these waters approximate to Group B in view of the high chloride content (>31%).

Group C: Temporary hard (carbonate) waters

(a) TDS values are generally in the range 250 - 400 mg ℓ^{-1}.

(b) The SiO_2 content is moderately low ranging from 6,5 - 11,0%.

(c) Low concentrations of chlorides in the range 5 - 8% are evident.

(d) The pH is consistently high with an approximate mean of 7,8.

(e) A relatively very high temporary hardness is the main characteristic of Group C waters. Approximately 68 - 90% of the TDS consists of $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. There is very little permanent hardness.

(f) Waters arising in the basic and ultra basic rocks of the Bushveld Igneous Complex (especially in the pyroxenic and ultra basic rocks) could be allocated to a sub-group, given that these waters consist very largely of $Mg(HCO_3)_2$ with an appreciable silica content. $Ca(HCO_3)_2$ is present in very small amounts.

(g) Group C waters are found in dolomite, the Ventersdorp System, the Pretoria shales and in the basic rocks of the Bushveld Igneous Complex.

Group D: Soda carbonate waters

(a) TDS values are variable in the range 245 - 700 mg ℓ^{-1}.

(b) The SiO_2 content is generally very high ranging from 12 - 18%.

(c) With the exception of Red granite waters, the chloride content is very low.

(d) With the exception of the Upper Beaufort waters, the SO_4 content is very low. Even in the Beaufort waters, the SO_4 content is not very high.

(e) The chief characteristic of these waters is the very high soda alkalinity, which usually ranges from 15 - 38% (as Na_2CO_3) and is due to $NaHCO_3$.

(f) In terms of the CaO : MgO ratio, there is generally more calcium than magnesium, except in certain Old granite waters.

(g) The pH varies between 7,4 - 8,2.

(h) In terms of hardness $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ seldom exceed 50% (as $CaCO_3$).

(i) These waters can be regarded as a sub-group of Group C (likewise carbonate waters). The only difference is that the alkalinity in Group C is mainly due to $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ whereas in Group D waters there is in addition, an appreciable amount of sodium bicarbonate and sometimes sodium carbonate. There is a considerable degree of overlap between the waters of Group C and Group D.

(j) Waters of Group D arise in the Middle and Upper Beaufort beds, the Stormberg sediments and lavas, Red granite, the Pilansberg alkali rocks, and in the Old granite of the northern Transvaal.

Group E: Pure water group

(a) Waters usually contain <150 mg ℓ^{-1} TDS, but may approach 20 - 40 mg ℓ^{-1} in the Pretoria quartzites.

(b) The SiO_2 content is generally high, especially in Old granite waters in the southern Transvaal. The exception is water from the Table Mountain Series in the Cape Province which approximates to the slightly saline Group B water.

(c) Moderately low chloride concentrations ranging from 8 - 14% are evident, with the exception of waters from the Table Mountain Series in Natal and the Cape Province, and the Witteberg quartzites with >30% Cl.

(d) In terms of the CaO : MgO ratio, MgO generally exceeds CaO.

(e) Waters are slightly acidic with a pH just under 7,0.

(f) The waters are all very soft.

(g) Group E waters are those arising in sandstones and quartzitic rocks of the Witwatersrand System, the Pretoria quartzites, Waterberg sandstones, the Table Mountain Series in Natal and the Cape, and in the Old granite of the southern Transvaal.

11.14.1 Some general observations regarding groundwater quality (according to Bond, 1946)

(a) Ecca waters in northern Natal do not conform to any type.

(b) The most saline waters in South Africa - excluding the Pondoland (Transkei) Dwyka springs which are rare - are those arising in the Old granite of the north west Cape which have a mean TDS concentration of nearly 7 000 mg ℓ^{-1}.

(c) The most alkaline waters in South Africa are those arising in the Upper Beaufort and Stormberg sediments, and in some of the Pilansberg alkali rocks.

(d) The most acidic waters in South Africa are the dark-coloured Table Mountain Series spring waters of the Cape.

(e) The purest waters are those arising in the quartzites and sandstones of the Pretoria Series, the Witwatersrand System and the Waterberg System.

(f) Waters with the highest percentage of silica are found in the granites and in the basic rocks of the Bushveld Igneous Complex. Waters arising in the basic rocks of the Bushveld Igneous Complex have the highest amount of silica of all waters in South Africa, with the exception of the few Pondoland springs.

(g) The highest percentage of sulphate is found in the Old granite waters of the north west Cape and in Dwyka waters of the Cape, western Transvaal and Pondoland.

(h) The waters with the least variation in percentage composition are those arising in dolomite.

(i) Group A waters are found in approximately two-fifths of South Africa, while Group D waters are found in one-third of the country.

(j) According to Bond (1946), with the exception of highly saline waters in the Cretaceous beds along the Natal North Coast, most of the groundwaters of Natal are comparatively pure (mainly Group E).

11.14.2 An examination of the Bond (1946) classification, with comments on northern Natal/KwaZulu

According to Van Wyk (1963)*, the classification by Bond (1946) is unreliable for most of northern Natal/KwaZulu. Van Wyk found that Bond's classification is too general to be of much practical value, due to insufficient data and/or unrepresentative sampling (including an over-emphasis on springs). Using the same general categories defined by

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* Discussion based on Van Wyk, W.L., 1963. Ground-water studies in northern Natal, Zululand and surrounding areas, Memoir No. 52, Geological Survey, Department of Mines, Pretoria, 135 p. and map.

Bond, Van Wyk proposed the following primary characteristics for four types of groundwater.

Group A: Highly mineralized chloride waters

(a) Waters usually contain >3 500 mg ℓ^{-1} TDS (Bond, 1946: 1 000 - 4 000 mg ℓ^{-1}).

(b) There is a high chloride content, which is generally >30% of TDS.

(c) Soda alkalinity (Na_2CO_3 or $NaHCO_3$) is never present.

(d) High salinity water is confined to the Cretaceous beds along the Natal North Coast, with most boreholes abandoned due to the high salinity.

Group B: Mineralized chloride waters

(a) TDS values range from 750 - 2 500 mg ℓ^{-1}, although there is little difference in percentage composition between Group A and B waters.

(b) Waters have a relatively high chloride content averaging 40% of TDS. Van Wyk (1963) maintained that the high salinity of the groundwaters is due to wind-borne salts derived from the Indian Ocean*.

(c) There is some difference in the composition of waters from the Stormberg lava and Karoo sediments. Main differences include:
   (i) The pH of water in the Karoo sediments averages 8,1 which is greater than in the basalt (7,1).
   (ii) The soda alkalinity (Na_2CO_3 or $NaHCO_3$) of water from the Karoo sediments is very low, while in the basalt, alkalinity averages >9%, up to 50% of TDS.

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* For a further discussion see Murgatroyd, A.L., 1983. Spatial variations in precipitation chemistry over Natal, South Africa, South African Journal of Science, VOL 79(10), p. 408 - 410.

(d) Waters of Group B are found in the fairly flat and bush-clad Lowveld areas, extending far inland along the flats and up the main river valleys.

Group C: Slightly saline waters

(a) TDS values are usually less than 600 mg ℓ^{-1}, although there is little difference in percentage composition between Group C, and Group A and B waters.

(b) Group C waters are evident in three different localities, namely the coastal zone, the Lebombo Mountains, and along the escarpment separating the Lowveld and Middleveld.

(c) In the coastal zone most of the Group C waters (found in Tertiary and Recent sands) overlie Group A waters present in the Cretaceous beds. Accordingly, in the False Bay area (St Lucia) where the sand is thin, all shallow boreholes and wells have Group C waters, while deep boreholes which penetrate the underlying Cretaceous beds, yield Group A waters. Further south however, in the vicinity of KwaMbonambi and Mposa the sand is more than 60 m deep and rests directly on granite and Karoo rocks. No highly mineralized waters are found even in deeper boreholes (at depths exceeding 90 m), which penetrate the underlying Cretaceous rocks. Waters of the higher reaches of the Lebombo Mountains where springs are plentiful, have a low percentage of (sea-derived) salts due to continual leaching. The leachate is discharged from the lower-lying springs and little concentration of salts can occur. By contrast, Group B waters are found in rhyolite in the flat, low-lying areas in the vicinity of Hluhluwe station and Ingweni (where springs are absent no leaching takes place). Van Wyk (1963) maintained that a similar process of leaching by springs also operates along the escarpment stretching from Eshowe through Melmoth, Mahlabatini, and Nongoma to Magudu in the north, with a low percentage of salts apparent.

Group D: Temporary hard (carbonate) waters

(a) TDS values average 276 mg ℓ^{-1} (Bond, 1946: generally <150 mg ℓ^{-1}) - equivalent to Bond's Group E.

(b) Chlorides are low, usually 10% of TDS.

(c) There is a high soda alkalinity with an average of 50% of the TDS, due to $NaHCO_3$ rather than Na_2CO_3.

(d) There is generally more Ca than Mg.

(e) There is very little permanent hardness.

(f) Group D waters are found further inland from Group C waters.

(g) A feature of waters in northern Natal is the occurrence of acid mine water in the coal mining areas. These waters create a serious pollution hazard. The water is not potable and is characterized by a pH of $<4{,}0$ with a high concentration of salts sometimes exceeding 4 000 mg ℓ^{-1}. A high SO_4 content (generally greater than 60% of TDS) is also evident.

Note: (i) Reference has already been made to the fact that few larger-scale groundwater surveys (especially involving detailed water quality studies), have been undertaken in Natal/KwaZulu. Smaller sub-regional studies, listed in the bibliographic database, should be examined for particular areas of interest.

(ii) The geological terminology used above refers to the publication in question. The source of the latest terminology is discussed in the chapter on geology.

(iii) According to Van Wyk (1970)* the groundwater temperature in Natal varies from 15°C in the Drakensberg to 24,8°C in the Lowveld and in the coastal zone. There is no seasonal temperature variation. The groundwater temperature is generally much the same as the mean summer air temperature at a particular locality.

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* See Van Wyk, W.L., 1970. Underground water in Natal, Paper No. 9, 2nd Technical Session, Symposium Water Natal 1970, 27 - 29 May 1970, Durban, 11 p., as well as Van Wyk, W.L., 1961. Die temperatuur van ondergrondse water in noord-Natal, Zoeloeland en omliggende gebiede, Tydskrif vir Natuurwetenskappe, VOL 1(3), p. 192 - 196.

11.15 Hygrophilous trees in Natal/KwaZulu

Table K8 provides a brief list of trees which are frequently associated with water bodies. These water bodies are, in many cases, quite obvious in the form of surface water but also occur as shallow groundwater. In the latter situation, the presence of hygrophilous trees is a useful indicator, especially in dry environments. In moist areas, hygrophilous vegetation is often less dependent on groundwater, and is therefore a less reliable indicator. Another factor which should be considered is that the occurrence of groundwater may be seasonal (see the chapter on wetlands and pans).

11.16 Grasses typical of wet areas in Natal/KwaZulu

Grasses found in wet areas are outlined in Table K9.

Table K8: Some hygrophilous trees in Natal/KwaZulu.

Botanical name	Common name
Bowkeria verticillata (Eckl. & Zeyh.) Schinz	Natal shell-flower bush
Breonardia microcephala (Delile) Ridsd.	Matumi
Cassipourea gummiflua Tul.	Onionwood
Commiphora ugogensis Engl.	River commiphora
Duvernoia adhatodoides E. Meyer ex Nees	Pistol bush
Englerodaphne pilosa Burtt Davy	Silky fibre-bush
Ficus sycomorus L.	Sycamore fig
Ilex mitis (L.) Radkl.	African holly
Macaranga capensis (Baillon) Benth.	Wild poplar
Maytenus mossambicensis (Klotzsch) Blakelock	Red forest spike-thorn
Phoenix reclinata L.	Wild date palm
Rauvolfia caffra Sond.	Quinine tree
Syzygium cordatum Hochst.	Umdoni
Tabernaemontana elegans Stapf	Toad tree
Tarenna laurentii (De Wild.) Garcia	-
Tarenna pavettoides (Harvey) T.R. Sim	Bastard bride's bush
Trichocladus ellipticus Eckl. & Zeyh.	White witch-hazel
Voacanga thouarsii Roemer & J.A. Schultes	Wild frangipani

<u>Source</u>: Edwards, T.J., 1989. Personal communication, Department of Botany, University of Natal, Pietermaritzburg.

<u>See also</u>:

(i) Smitter, Y.H., 1955. Plants as indicators of ground water in southern Africa, <u>Trees in South Africa</u>, VOL 7(3), p. 6 - 10.

(ii) Van Wyk, W.L., 1963. Ground-water studies in northern Natal, Zululand and surrounding areas, Memoir No. 52, Geological Survey, Department of Mines, Pretoria, 135 p. and map. (Brief reference is made to hygrophilous trees in this publication).

Table K9: Common grasses in Natal/KwaZulu found on wet soils.

Botanical name	Common name
Acroceras macrum	Nile grass
Andropogon eucomus	Snowflake grass
Bothriochloa glabra	Purple plumed grass
Brachiaria serrata	Velvet signalgrass
Bromus wildenowii	Rescue grass
Cymbopogon validus	Giant turpentine-grass
Dactylis glomerata	Cocksfoot
Digitaria smutsii	Smuts' fingergrass
Echinochloa crus-galli	Barnyard millet
Eragrostis plana	Fan lovegrass
Festuca arundinacea	Tall fescue
Hemarthria altissima	Red swampgrass
Hyparrhenia aucta & H. rufa	Giant thatchgrass
Hyparrhenia filipendula	Fine thatchgrass
Imperata cylindrica	Cottonwool grass
Leersia hexandra	Wild ricegrass
Miscanthidium capense	East-coast broomgrass
Monocymbium ceresiiforme	Wild oatgrass
Paspalum dilatatum	Common paspalum
Paspalum notatum	Lawn paspalum
Paspalum urvillei	Giant paspalum
Pennisetum clandestinum	Kikuyu

Table K9: Common grasses in Natal/KwaZulu found on wet soils (continued).

Botanical name	Common name
Poa annua	Annual bluegrass
Setaria chevalieri	Broadleaved setaria
Setaria sphacelata	Golden setaria
Stenotaphrum secundatum	Coastal buffalo grass

Source: After Tainton, N.M., Bransby, D.I. and Booysen, P. de V., 1979. Common Veld and Pasture Grasses of Natal, Shuter and Shooter, Pietermaritzburg, 198 p.

Note: The above publication discusses grass species in forests and forest margins, as well as species found in compacted, shallow, fertile and sandy soils. Species typical of sweet, mixed and sour open grassveld are also outlined. Grasses found on old lands, and in overgrazed and over-rested veld are likewise listed. Summer and winter pasture grasses plus grasses typical of the 11 bioclimatic groups are described. The following publication also provides a list of grasses as indicator species with regard to the general condition of soils, as well as species typical of soil and veld types: Du Toit, P.C.V., 1986. The grassveld types of South Africa: their distribution, characteristics and management, with particular reference to Natal, Cedara Report No. N/A/86/7, Department of Agriculture and Water Supply (Natal Region), Cedara, 21 p. + app.

11.17 Some primary publications on groundwater in South Africa*

11.17.1 General

- Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

- Anonymous, 1987. Borehole Water Association of Southern Africa: minimum code of practice for borehole construction and pump installation, Borehole Water Association of Southern Africa, Johannesburg, 19 p. (Advisory publications are

* Numerous technical reports on a variety of groundwater issues are available from the Directorate of Geohydrology, Department of Water Affairs and Forestry, Pretoria - see the bibliographic database. The Institute for Groundwater Studies, University of the Orange Free State, Bloemfontein, has likewise produced a considerable number of publications. The Institute however, has not undertaken any groundwater surveys in Natal/KwaZulu.

also obtainable from the Groundwater Division, Geological Society of South Africa, P O Box 44283, Linden, 2104).

- Anonymous, [1990]. Groundwater: guidelines for boreholes, Borehole Water Association of Southern Africa, the Division of Earth, Marine and Atmospheric Science and Technology of the CSIR, the Department of Agricultural Development, the Department of Water Affairs and the Geological Society of South Africa, Pretoria, 29 p. (The publication is written in a non-technical style and revises a previous report namely, Miller, P.M., undated. Know your own borehole, Borehole Water Association of Southern Africa, Johannesburg, 36 p.).

- Bond, G.W., 1946. A geochemical survey of the underground water supplies of the Union of South Africa with particular reference to their utilisation in power production and industry, Memoir No. 41, Geological Survey, Department of Mines, Pretoria, 216 p.

- Botha, W.J. (ed), 1992. Evaluation of electromagnetic exploration techniques in groundwater exploration, WRC Report No. 212/1/92, Water Research Commission, Pretoria, 214 p. + app.

- Bredenkamp, D.B., 1995. Dolomitic groundwater resources of the Republic of South Africa: Part 1, Critical aspects in the management of dolomitic aquifers, and Part 2, Characteristics of dolomitic aquifers with special reference to man's impact on these resources, Technical Report No. Gh 3857, Directorate of Geohydrology, Department of Water Affairs and Forestry, Pretoria, 54 p. + app.

- Bredenkamp, D.B., Botha, L.J., Van Tonder, G.J. and Janse van Rensburg, H., 1995. Manual on quantitative estimation of groundwater recharge and aquifer storativity: based on practical hydro-logical methods, WRC Report No. TT 73/95, Water Research Commission, Pretoria, 363 p. + app. (The report is an important document which should be carefully examined by readers interested in the topic).

- Campbell, E.E., Parker-Nance, T. and Bate, G.C., 1992. A compilation of information on the magnitude, nature and importance of coastal aquifers in southern Africa, WRC Report No. 370/1/92, Water Research Commission, Pretoria, 192 p. (The publication has a useful list of references).

- Cogho, V.E., Kirchner, J. and Morris, J.W., 1989. A National Ground-water Data Base for South Africa - development of the data base, WRC Report No. 150/1/89, Water Research Commission, Pretoria, 276 p.

- Cogho, V.E., Kirchner, J. and Morris, J.W., 1989. A National Ground-water Data Base for South Africa - user's guide, WRC Report No. 150/2/89, Water Research Commission, Pretoria, various pages.

- Connelly, R.J., Abrams, L.J. and Schultz, C.B., 1989. An investigation into rainfall recharge to ground water: technical report, WRC Report No. 149/1/89, Water Research Commission, Pretoria, 138 p. + app. (The report has a useful bibliography).

- Connelly, R.J., Abrams, L.J., Schultz, C.B., Chipps, R.J. and Hearne, C.L., 1989. An investigation into rainfall recharge to ground water: appendix report, WRC Report No. 149/2/89, Water Research Commission, Pretoria, various pages. (The appendix report contains useful data for the De Hoek/Ntabamhlope research catchments near Estcourt. See the chapter on the surface water resources of Natal/KwaZulu).

- Division of Water Technology, CSIR, 1993. Part 1: Guidelines on the cost effectiveness of rural water supply and sanitation projects, 35 p. Part 2: Guidelines on the technology for and management of rural water supply and sanitation projects, 191 p. + app., WRC Report No. 231/1/93, Water Research Commission, Pretoria. (The report discusses inter alia some technological aspects of borehole pumps, well drilling and spring protection).

- Enslin, J.F., 1964. Hydrological memoir on ground-water supplies in the Republic of South Africa and their development, use and control, Division of Hydrological Research, Department of Water Affairs, Pretoria, 42 p. (The publication is a useful, although somewhat dated, overview document).

- Hofkes, E.H. (ed), 1983. Small Community Water Supplies: Technology of Small Water Supply Systems in Developing Countries, International Reference Centre for Community Water Supply and Sanitation and John Wiley and Sons, Chichester, 442 p. (The book is available at the Life Sciences Library, University of Natal, Pietermaritzburg).

- Kirchner, J.O.G., 1995. Investigation into the contribution of ground water to the salt load of the Breede River, using natural isotopes and chemical tracers, WRC Report No. 344/1/95, Water Research Commission, Pretoria, 335 p. (The report is a useful case study).

- Kirchner, J. and Van Tonder, G.J., 1995. Proposed guidelines for the execution, evaluation and interpretation of pumping tests in fractured-rock formations, Water SA, VOL 21(3), p. 187 - 200.

- Kirchner, J., Van Tonder, G.J. and Lukas, E., 1991. Exploitation potential of Karoo aquifers, WRC Report No. 170/1/91, Water Research Commission, Pretoria, 283 p.

- Kirchner, J., Van Tonder, G.J. and Lukas, E., 1991. Exploitation potential of Karoo aquifers: appendix, WRC Report No. 170/2/91, Water Research Commission, Pretoria, 244 p.

- Lynch, S.D., Reynders, A.G. and Schulze, R.E., 1994. Preparing input data for a national-scale groundwater vulnerability map of southern Africa, Water SA, VOL 20(3), p. 239 - 246.

- Meyer, R. and Coetsee, V. d A., 1991. Die toepassing van geoëlektriese metodes vir die bepaling van geohidrologiese veranderlikes, WRC Report No. 216/1/91, Water Research Commission, Pretoria, 55 p. + app.

- Paling, W.A.J. and Stephenson, D., 1993. Effects of urbanization on catchment water balance, 3. Geohydrology of catchments, WRC Report No. 183/3/93, Water Research Commission, Pretoria, 155 p.

- Parsons, R., 1995. A South African aquifer system management classification, WRC Report No. KV 77/95, Water Research Commission, Pretoria, 20 p. + app. (The report, which deals with groundwater pollution issues, has a useful glossary of South African groundwater terms).

- Rudolph, D.C., Kirchner, J. and Botha, J.F., 1992. Investigations into variable head tests for the determination of aquifer parameters, WRC Report No. 272/1/92, Water Research Commission, Pretoria, 64 p.

- Simpson, G.C., 1990. Research into groundwater abstraction in residential areas, VOL 1, WRC Report No. 211/1/90, Water Research Commission, Pretoria, 56 p. + app.

- Simpson, G.C., 1990. Data from the research into groundwater abstraction in residential areas, VOL 2, WRC Report No. 211/2/90, Water Research Commission, Pretoria, 186 p. (The Simpson reports refer to Pretoria and constitute a useful survey of urban residential groundwater consumption patterns in drought situations).

- Van Tonder, G.J. and Cogho, V.E., 1987. AQUAMOD: 'n twee-dimensionele Galerkin eindige element simulasieprogram vir mikrorekenaars vir die voorspelling van versadigde grondwatervloei en besoedeling, Water SA, VOL 13(3), p. 175 - 180.

- Van Wyk, W.L., 1961. Die temperatuur van ondergrondse water in noord-Natal, Zoeloeland en omliggende gebiede, Tydskrif vir Natuurwetenskappe, VOL 1(3), p. 192 - 196.

- Van Wyk, W.L., 1963. Ground-water studies in northern Natal, Zululand and surrounding areas, Memoir No. 52, Geological Survey, Department of Mines, Pretoria, 135 p. and map.

- Vegter, J.R., 1990. Groundwater regions and subregions of South Africa, Technical Report No. Gh 3697, Directorate of Geohydrology, Department of Water Affairs and Forestry, Pretoria, 52 p.

- Vegter, J.R., 1995. Groundwater resources of South Africa: an explanation of a set of national groundwater maps, WRC Report No. TT 74/95, Water Research Commission, Pretoria, various pages. (Refer to the chapter on maps for a description of the maps in question, as well as another important groundwater map).

- Verwey, J.P. and Botha, J.F., 1992. A comparative study of two - and three - dimensional groundwater models, VOL 1, WRC Report No. 271/1/92, Water Research Commission, Pretoria, 97 p.

- Visser, F., 1987. Ground-water law in South Africa, Tydskrif vir Hedendaagse Romeins-Hollandse Reg, VOL 50(4), p. 412 - 427.

11.17.2 Natal/KwaZulu survey reports (as per mapping unit)*

Note: Natal/KwaZulu including the northern part of the Transkei, was divided into 11 mapping units for the purposes of the survey.

- Davies Lynn and Partners, 1995. Characterization and mapping of the groundwater resources of the KwaZulu Natal Province, mapping unit 4, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 102 p. + app. (South eastern districts to the Transkei border).

- Davies Lynn and Partners, 1995. Characterization and mapping of the groundwater resources of the KwaZulu Natal Province, mapping unit 8, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 43 p. + app. (Environs of Estcourt to Ixopo).

- E. Martinelli and Associates, 1994. Characterization and mapping of the groundwater resources of mapping unit 1 of the KwaZulu/Natal Province,

* An overview document containing background information is also available. See Hobbs, P.J., 1993. Department of Water Affairs and Forestry Directorate: Geohydrology: Natal/KwaZulu hydrogeological mapping project - results of Phases 1 and 2, final report, November 1993, Groundwater Consulting Services, Johannesburg, various pages + app.

[Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 111 p. + app. (Environs of Melmoth).

- E. Martinelli and Associates, 1995. Characterization and mapping of the groundwater resources of mapping unit 5 of the KwaZulu-Natal Province, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 123 p. + app. (Environs of Vryheid).

- Groundwater Consulting Services, 1995. KwaZulu-Natal groundwater characterization and hydrogeological mapping programme: report on the groundwater resources and hydrogeology of unit 2, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 37 p. + app. (Environs of Pietermaritzburg).

- Groundwater Development Services, 1995. Hydrogeological characterization and mapping of the KwaZulu-Natal Province, mapping unit 3: final report, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 58 p. + app. (Eshowe to the Swaziland/Mozambique border).

- Groundwater Development Services, 1995. Hydrogeological characterization and mapping of the KwaZulu-Natal Province, mapping unit 6: final report, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 66 p. + app. (Coastal zone from Mtunzini to the Transkei border).

- Groundwater Development Services, 1995. Hydrogeological characterization and mapping of the KwaZulu-Natal Province, mapping unit 10: final report, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 58 p. + app. (Environs of Kokstad and East Griqualand).

- Magda, L. and Cameron-Clarke, I.S., 1995. Report on KwaZulu/Natal hydrogeological mapping project, area 9, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 57 p. + app. (Environs of Ladysmith).

- Meyer, R. and Godfrey, L., 1995. KwaZulu-Natal geohydrological mapping project, mapping unit 7, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 38 p. + app. (Environs of Richards Bay to the Mozambique border).

- VSA Earth Science Consultants, 1995. KwaZulu-Natal groundwater characterization and hydrogeological mapping programme: report on the groundwater resources and hydrogeology of unit 11, [Directorate of Geohydrology], Department of Water Affairs and Forestry, Pretoria, 73 p. + app. (Environs of Newcastle).

For further information contact:

Note: A considerable amount of highly localized groundwater data can be found in reports produced by various consulting engineering firms (especially those with geotechnical expertise). See the bibliographic database. Both locational and/or hydrogeological data can be obtained from some of the organizations listed below. Alternatively, reports containing relevant groundwater information may be held by the organization concerned. Other agencies can provide advice on the technical aspects of boreholes, wells and springs.

Boreholes and wells

- Borehole Water Association of Southern Africa, P O Box 2178, Southdale, 2135.

- Computing Centre for Water Research/Department of Agricultural Engineering, University of Natal, Private Bag X01, Scottsville, 3209.

- Department of Hydrology, University of Zululand, Private Bag X1001, KwaDlangezwa, 3886.

- Directorate of Geohydrology, Department of Water Affairs and Forestry, Private Bag X313, Pretoria, 0001/Private Bag X9052, Cape Town, 8000.

- Directorate of Soil Conservation and Drilling Services, Department of Agriculture, P O Box 299, Ladysmith, 3370/Private Bag X515, Silverton, 0127.

- Division of Earth, Marine and Atmospheric Science and Technology, CSIR, P O Box 320, Stellenbosch, 7599.

- Division of Water Technology, CSIR, P O Box 395, Pretoria, 0001.

- Geological Survey, Department of Mineral and Energy Affairs, P O Box 900, Pietermaritzburg, 3200/Private Bag X112, Pretoria, 0001.

- Groundwater Association of KwaZulu-Natal, P O Box 52042, Berea Road, 4007.

- Groundwater Division, Geological Society of South Africa, P O Box 44283, Linden, 2104.

- Institute for Groundwater Studies, University of the Orange Free State, P O Box 339, Bloemfontein, 9300.

- KwaZulu Department of Agriculture and Forestry, Private Bag X05, Ulundi, 3838.

- Mhlatuze Water, P O Box 1264, Richards Bay, 3900.

- National Physical Modelling Facility, Department of Geology, University of Pretoria, Pretoria, 0002. (The Department undertakes advanced groundwater exploration modelling procedures).

- Port Natal/Ebhodwe Joint Services Board, P O Box 1520, Durban, 4000/Southern Natal Joint Services Board, P O Box 33, Port Shepstone, 4240/Thukela Joint Services Board, P O Box 116, Ladysmith, 3370/Zululand Joint Services Board, Private Bag X1025, Richards Bay, 3900.

- Rural Water Trust, P O Box 10823, Marine Parade, 4056.

- Umgeni Water, P O Box 9, Pietermaritzburg, 3200.

Springs

- Africa Co-operative Action Trust-Southern Africa, P O Box 2763, Pietermaritzburg, 3200.
- Amatikulu Primary Health Centre, KwaZulu Department of Health, Private Bag X2113, Nyoni, 3802. (The Centre has a small static display of various items of appropriate technology, mainly consisting of borehole handpumps).
- Directorate of Community Development, Community Services Branch, Natal Provincial Administration, Private Bag X9037, Pietermaritzburg, 3200.
- Division of Water Technology, CSIR, P O Box 395, Pretoria, 0001.
- Institute of Natural Resources, University of Natal, Private Bag X01, Scottsville, 3209.
- KwaZulu Department of Agriculture and Forestry, Private Bag X05, Ulundi, 3838.
- Port Natal/Ebhodwe Joint Services Board, P O Box 1520, Durban, 4000/Southern Natal Joint Services Board, P O Box 33, Port Shepstone, 4240/Thukela Joint Services Board, P O Box 116, Ladysmith, 3370/Zululand Joint Services Board, Private Bag X1025, Richards Bay, 3900.
- Thuthuka, P O Box 4078, Durban, 4000.
- Umgeni Water, P O Box 9, Pietermaritzburg, 3200.
- Valley Trust, P O Box 33, Botha's Hill, 3660.
- World Vision of Southern Africa, P O Box 17364, Congella, 4013.

NOTES:

NOTES:

CHAPTER 12: WATER SUPPLY PLANNING FOR INFRASTRUCTURE PROVISION

The daily burden of fetching water...

Portrait of love

She's old now, my wife;
She is old under those
Four gallons of water,
(It was said taps in the streets
Would be our new rivers).
But my wife fetches the water
(Down Second Avenue)...

N.S. Ndebele, quoted in Chapman, M. (ed), 1982. A Century of South African Poetry, AD. Donker, Johannesburg, 397 p. (Note: Water is generally carried in a 20 or 25 ℓ container, usually on the head, or sometimes in a wheelbarrow (1 gallon equals approximately 4,5 ℓ - see Chapter 20 for an exact conversion). The phrase "Down Second Avenue", may well have been taken from the following: Mphahlele, E., 1971. Down Second Avenue, new edition, Faber and Faber, London, 222 p.).

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12.1 Introduction

The aim of this chapter is to provide selected core information on water supply planning - and to some extent sanitation - with special reference to urban areas in South Africa. Additional information relevant to the discussion can be found in the chapter on the surface water resources of Natal/KwaZulu, as well as in the chapters on groundwater, solid waste management, sanitation, and health. The present chapter is divided into three parts. The first section examines animal, domestic and industrial water consumption, as a prelude to a brief overview of certain design guidelines for water (and sanitation) planning. Some training programmes in terms of water and sanitation are then described. The final section deals with a number of related issues, namely, demographic information, settlement categories and housing systems.

The Water Research Commission has released a number of reports dealing with various aspects of the planning and design of (mainly urban) water supply systems in South Africa*. Readers requiring an holistic perspective should carefully examine the reports which cover a number of topics including overall future water demand patterns; policies for infrastructure delivery and international perspectives on the provision of services; the cost of water systems and methods of financing, as well as some macro-economic

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* See Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 1. Overview of institutional and financial arrangements in water supply and sanitation, with a focus on the urban areas of South Africa, WRC Report No. 571/1/94, Water Research Commission, Pretoria, 231 p. + app., plus Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 2. Overview of the demand for and costs of water supply and sanitation services in South Africa, WRC Report No. 571/2/94, Water Research Commission, Pretoria, 22 p. + app., and Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 3. Meeting the demand for water and sanitation services: getting it right in the transition, WRC Report No. 571/3/94, Water Research Commission, Pretoria, 101 p. + app., as well as Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 4. International perspectives - some lessons for South Africa from England, France, Italy, Brazil and Botswana and some information on external funding agencies, WRC Report No. 571/4/94, Water Research Commission, Pretoria, 35 p., read together with Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 5. Macro-economic sketch - a sketch of the macro-economic implications of major investment in the (domestic) urban water and sanitation sector, WRC Report No. 571/5/94, Water Research Commission, Pretoria, 40 p., and finally, Palmer Development Group, 1994. Water and sanitation in urban areas: financial and institutional review, Report 6. Summary report, WRC Report No. 571/6/94, Water Research Commission, Pretoria, 59 p. See also, Palmer, I. and Eberhard, R., 1994. Evaluation of water supply to developing urban communities in South Africa, Phase 1 - overview, WRC Report No. KV 49/94, Water Research Commission, Pretoria, various pages, as well as Palmer, I. and Eberhard, R., 1995. Evaluation of water supply to developing urban communities: summary report, WRC Report No. KV 73/95, Water Research Commission, Pretoria, 81 p. See in addition: Palmer Development Group, 1994. Water and sanitation in urban areas: survey of on-site conditions, WRC Report No. 561/1/94, Water Research Commission, Pretoria, 63 p. + app.

implications of major investments in water and sanitation schemes. Cost factors are of vital importance in South Africa*. It is clear that the cost of water per se - and the cost of delivery - will increase markedly over time, partly as an economic rationing mechanism to contain excessive demand, and also with reference to future droughts. Higher water revenues will be used to fund the supply of purified water to approximately 12 000 - 15 000 rural, peri-urban and urban settlements.

The Department of Water Affairs and Forestry recently launched a National Water Conservation Campaign to facilitate the efficient, sustainable and equitable supply as well as use of water (see later in the chapter). A core objective is to educate consumers to save water. The detection and repair of leaks in major urban networks is accordingly essential**. Strategies include water audits; incentives for good conservation practices/penalties for poor water management; higher tariffs, and stricter control of pollution. Several projects are underway such as a schools water awareness programme, the removal of invasive alien vegetation in selected river catchments, and an investigation into prepayment metering for low income households.

12.2 Animal, domestic and industrial water consumption in South Africa

Some relevant water consumption information is presented in this section. Tables L1 and L2 provide data for wild animals and livestock respectively. Domestic (both urban and peri-urban/rural) data are outlined in Tables L3 - L6, while industrial consumption data are presented in Table L7. The latter table includes industrial water quality information (see the chapter on water quality, elsewhere in this publication). Further domestic (design)

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* Useful publications/papers on the costs of water and water systems include the following: Mirrilees, R.I., Forster, S.F. and Williams, C.J., 1994. The application of economics to water management in South Africa, WRC Report No. 415/1/94, Water Research Commission, Pretoria, various pages, as well as Schur, M.A., 1994. The need to pay for services in the rural water sector, South African Journal of Economics, VOL 62(4), p. 419 - 431., read together with Schur, M.A., 1994. The cost of rural water supply: a case study in South Africa, Water SA, VOL 20(3), p. 179 - 186. See in addition: Stephenson, D., 1995. Factors affecting the cost of water supply to Gauteng, Water SA, VOL 21(4), p. 275 - 280., plus Van Ryneveld, M.B., 1994. The current extent of coverage and the costs of water supply and sanitation provision in the urban areas of South Africa, Water SA, VOL 20(2), p. 99 - 106., and Van Ryneveld, M.B., 1995. Costs and affordability of water supply and sanitation provision in the urban areas of South Africa, Water SA, VOL 21(1), p. 1 - 14.

** A brief, non-technical overview of water loss procedures can be found in Malan, G.J., 1994. Municipal water loss management: guidelines for water supply authorities, Municipal Engineer, VOL 25(7), p. 23 - 26. (See the bibliographic database).

water consumption and related data, with specific reference to black settled areas, are given later in the chapter.

Table L1: A broad overview of water consumption by wild animals in South Africa.

Species	Details
African elephant (Loxodonta africana)	African elephants can draw up to 17,5 ℓ of water (via the trunk) at a particular time, and can consume up to 322 ℓ on a single occasion. A distinction must be made between water required for physiological (drinking) needs (83% of total consumption) and water required for spraying (cooling) purposes (17% of total consumption). An African elephant of average size (approximately 2 045 kg) normally uses 163,8 ℓ of water at a time, visits watering-places on average every 43,4 hours (in winter), and consumes 90,6 ℓ of water in a 24 hour period. Large bulls normally use 356,5 ℓ of water at a time or 197,3 ℓ every 24 hours. Under extreme conditions, elephants can visit up to 15 water-containing veld pans a day in summer. During dry winter months, elephants may sometimes remain without water for more than three days. An elephant of average size uses the daily water equivalent of four buffaloes; or six zebra; or 11 wildebeest, or 66 impala of average size
Buffalo (Syncerus caffer)	Buffaloes usually drink 34,5 ℓ of water at a time and visit watering-places approximately once every 38 hours (in winter). An individual buffalo consumes 21,6 ℓ of water on a daily basis in winter. Buffaloes visit watering-places more frequently in summer
Blue wildebeest (Connochaetes taurinus)	Blue wildebeest drink 16,6 ℓ of water at a time and visit watering-places approximately once every 46,9 hours in winter. Average daily consumption is some 8,7 ℓ of water per animal during winter
Burchell's zebra (Equus burchellii antiquorum)	Zebras usually drink some 14,7 ℓ of water in a 24 hour cycle. They visit watering-places once every 35,2 hours in winter, consuming an average of 21,6 ℓ of water per animal
Impala (Aepyceros melampus)	Impala drink approximately 4,1 ℓ of water at a time or 1,4 ℓ in a 24 hour period. In winter, impala normally drink once every 68,4 hours. During severe droughts, impala can remain without water for five or more days. It has been found that impala (in the Kruger National Park), can survive for unspecified periods without drinking water

Source: After Young, E., 1972. The water requirements of wild animals in the Kruger National Park, Custos, VOL 1(6), p. 31 - 35.

See also: (i) David, J.H.M., 1973. Observations on frequency of drinking in the bontebok, Damaliscus dorcas dorcas, Zoologica Africana, VOL 8(1), p. 135 - 137.

(ii) Young, E., 1970. Water as faktor in die ekologie van wild in die Nasionale Krugerwildtuin, D.Sc. Thesis, Department of Wildlife Management, University of Pretoria, Pretoria, 192 p.

(iii) Young, E., 1970. Water in game management, Water Year 1970, Convention on Water for the Future, [Department of Water Affairs], 16 - 20 November 1970, Pretoria, 7 p. (Some slight differences in the data are evident vis-a-vis Young, 1972 - above).

Note: (i) The data refer to the Kruger National Park. Winter consumption was assessed since the dry season represents a critical period when natural watering-places are sparse. Accordingly, the data refer to consumption patterns at artificial water-holes installed by Park authorities. During summer, game frequent a much higher proportion of natural watering-places (rivers and pans), where (summer) consumption data would be impossible to derive. The higher moisture content (and availability) of grazing in summer is also a factor influencing water demand.

(ii) Elephants, buffaloes, blue wildebeest, zebra and impala, representing a large majority of the more than 250 000 bigger mammals in the Kruger National Park at the time of the survey, consumed an estimated 1 784 340 ℓ of water a day. In terms of respective body size buffaloes, blue wildebeest and impala all consume approximately the same daily volume of water, namely, 4% of their body mass (some 0,04 ℓ kg^{-1}).

(iii) According to Young (1970 (iii)), preliminary investigations in the Kruger National Park in winter, suggested a mean feeding radius from the nearest water of 5,9 km for elephants; 7,8 km for buffaloes; 7,4 km for blue wildebeest; 7,2 km for zebra, and 2,2 km for impala. The concentration of game around watering-places often exposes the adjacent areas to excessive trampling, overgrazing and soil erosion*.

(iv) The water supply situation in the Kruger National Park has now assumed serious proportions. The possibility exists that (water-related) culling of some larger mammals might be required in the future, unless other sources of water can be found. An interesting

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* See Thrash, I., Nel, P.J., Theron, G.K. and Bothma, J. du P., 1991. The impact of the provision of water for game on the basal cover of the herbaceous vegetation around a dam in the Kruger National Park, Koedoe, VOL 34(2), p. 121 - 130., as well as Thrash, I., Nel, P.J., Theron, G.K. and Bothma, J. du P., 1991. The impact of the provision of water for game on the woody vegetation around a dam in the Kruger National Park, Koedoe, VOL 34(2), p. 131 - 148. See in addition, Weir, J. and Davison, E., 1965. Daily occurrence of African game animals at waterholes during dry weather, Zoologica Africana, VOL 1(2), p. 353 - 368. Examine likewise Owen-Smith, N., 1996. Ecological guidelines for waterpoints in extensive protected areas, South African Journal of Wildlife Research, VOL 26(4), p. 107 - 112.

study of reduced water and electricity consumption by visitors to the Park (with widespread ramifications), is the following: Preston, G., 1994. The effects of a user-pays approach, and resource-saving measures, on water and electricity use by visitors to the Kruger National Park, South African Journal of Science, VOL 90(11/12), p. 558 - 561.

(v) Some health implications of very brackish water ingested by game are briefly discussed in: Bothma, J. du P. (ed), 1989. Game Ranch Management: a Practical Guide on All Aspects of Purchasing, Planning, Development, Management and Utilization of a Modern Game Ranch in Southern Africa, J.L. Van Schaik, Pretoria, 672 p. (An updated and revised edition of the book was published in 1996).

Table L2: A broad overview of water consumption by livestock.

Species	Body mass (kg)	Condition	Water consumption (ℓ day^{-1})
Cattle			
4 weeks	51	Growing	4,9 - 5,7
8 weeks	69	Growing	6,1 - 7,6
12 weeks	93	Growing	8,7 - 9,5
16 weeks	119	Growing	11,7 - 13,2
20 weeks	148	Growing	15,1 - 17,0
26 weeks	189	Growing	17,0 - 22,7
60 weeks	353	Growing	22,7 - 30,3
84 weeks	464	Pregnant	30,3 - 37,9
1 - 2 years	454 - 544	Fattening	30,3 - 34,1
2 - 8 years	544 - 726	Lactating	37,9 - 94,6
2 - 8 years	544 - 726	Grazing	17,0 - 34,1
Swine	14	Growing	1,1 - 3,8
	27 - 36	Growing	2,6 - 4,5
	36 - 57	Growing	3,8 - 7,6
	91 - 181	Maintenance	5,7 - 13,2
	91 - 181	Pregnant	15,1 - 18,9
	91 - 181	Lactating	18,9 - 24,6

Table L2: A broad overview of water consumption by livestock (continued).

Species	Body mass (kg)	Condition	Water consumption (ℓ day^{-1})
Sheep	9	Growing	1,9
	23	Growing	1,5
	68 - 91	Grazing	1,9 - 5,7
	68 - 91	Grazing, salty feeds	7,9
	68 - 91	Hay and grain	0,4 - 3,0
	68 - 91	Good pasture	<1,9
Chickens (per 100 birds)			
1 - 3 weeks	-	Growing	1,9 - 7,6
3 - 6 weeks	-	Growing	5,7 - 11,4
6 - 10 weeks	-	Growing	11,4 - 15,1
9 - 13 weeks	-	Growing	15,1 - 18,9
Mature	-	Non-laying hens	18,9
Mature	-	Laying	18,9 - 28,4
Mature (32°C)	-	Laying	34,1
Turkeys (per 100 birds)			
1 - 3 weeks	-	-	4,2 - 9,8
4 - 7 weeks	-	-	1,5 - 32,2
9 - 13 weeks	-	-	34,1 - 54,9
15 - 19 weeks	-	-	63,2 - 64,4
21 - 26 weeks	-	-	51,1 - 56,8
Mature	-	-	64,4
Horses (mature)	-	-	45,4

<u>Source</u>: After Ensminger, M.E. and Olentine, C.G., 1980. <u>Feeds and Nutrition - Complete</u>, Ensminger Publishing Company, Clovis, USA, 1417 p. The data, drawn from a later edition, are reproduced in: Anonymous, 1993. South African water quality guidelines, VOL 4, Agricultural use, Department of Water Affairs and Forestry, Pretoria, 286 p. (Note: Some metric conversion errors and missing data are evident in Anonymous, 1993).

<u>See also</u>: Zeeman, P.J.L., 1983. Die rol van water by herkouers, <u>Karoo Agric</u>, VOL 2(4), p. 10 - 12.

Note: (i) Animal water requirements are determined by both physiological and environmental factors. Physiological parameters include animal breed, stage of physiological development, gestation, lactation and physical activity; as well as the type of feed and dry matter plus inorganic salt intake - reflecting veld condition or feeding in intensive systems. Environmental factors are air temperature, humidity, evaporation and wind (reflecting season). These parameters also apply to wild animals.

(ii) Washing and cooling water required (per cow) for the cow-shed and the dairy has been estimated at 45 ℓ day^{-1} (Perold, R.P., 1957. B. Water supply on the farm. Water requirements for home and farmyard, In: Handbook for Farmers in South Africa, VOL 1: Agriculture and Related Services, Department of Agriculture, Pretoria, p. 527 - 529).

(iii) For planning purposes it is always advisable to allow for a factor of safety - due to variable dietary as well as production and environmental factors - in estimating the daily volume of water required for livestock. In this regard it should be noted, for example, that beef cattle generally consume less water than lactating dairy cattle. The Department of Agriculture should be approached for more precise South African data for specific climatic regions.

Table L3: Some South African domestic water consumption category data for formal urban households.

Use category	Details
Bath (one person once a day)	120 ℓ at a time or 43 800 ℓ annually
Shower (one person once a day)	75 ℓ at a time or 27 375 ℓ annually
Washing hands under running water	Up to 5 ℓ at a time*
Toilet (one person at 11 ℓ per flush)	55 ℓ day^{-1} or 20 075 ℓ annually
Dripping tap (50 drops a minute)	1 838 ℓ annually
Kettle and stove	90 minutes day^{-1} = 32 850 ℓ annually
Washing of dishes in the kitchen sink	Up to 18 ℓ day^{-1}*
Dishwasher (once a day)	30 - 60 - 150 ℓ at a time or 10 950 - 21 900 - 54 750 ℓ annually
Automatic washing machine (three times a week) Note: Automatic washing machines use considerably more water than ordinary washing machines	150 ℓ at a time or 23 400 ℓ annually
Swimming pool (without cover)	50 000 ℓ, up to 4 000 ℓ at a time to top up the pool*

Table L3: Some South African domestic water consumption category data for formal urban households (continued).

Use category	Details
Car washing (once a week for eight minutes using a hosepipe) Note: Use of a hosepipe rather than a bucket results in a ten-fold increase in water consumption	6 240 ℓ annually
Garden sprinkler	Up to 1 500 ℓ h^{-1}*

<u>Source</u>: (i) After the Department of Water Affairs and Forestry, Pretoria, 1993.

(ii) After Umgeni Water, Pietermaritzburg, 1993 (data marked with an asterisk).

<u>Note</u>: (i) The National Building Research Institute (now the Division of Building Technology) of the CSIR, provided data for a typical dwelling with four (white) occupants which illustrates the reduction in water consumption (some 40%), which could be achieved by ordinary householders without drastic lifestyle changes. The data concern mean daily indoor water consumption (see below).

Use category	Consumption by a non-water saving household		Consumption by a water saving household	
Bath	Two baths at a depth of 150 mm	180 ℓ	One bath at a depth of 100 mm	80 ℓ
Shower	Two showers at 7,5 ℓ min^{-1} for five minutes each	75 ℓ	Three showers at ± 6 ℓ min^{-1} for four minutes each (taps closed while soaping)	70 ℓ
Wash basin	Water used freely	30 ℓ	Water used carefully	20 ℓ
Toilet	16 uses at ± 12 ℓ per flush	190 ℓ	Volume of flush reduced and short flushes used as necessary	70 ℓ
Cooking and drinking	As per needs	15 ℓ	As per needs	15 ℓ
Dish washing	Sink filled with water each time	40 ℓ	Water used sparingly	20 ℓ
Twin-tub washing machine	Per wash cycle	90 ℓ	Per wash cycle	90 ℓ
Hand washing of clothes, floors, windows and other items	Water used carelessly	20 ℓ	Water used sparingly	15 ℓ
Mean consumption	160 ℓ $capita^{-1}$ day^{-1} x 4 =	640 ℓ	95 ℓ $capita^{-1}$ day^{-1} x 4 =	380 ℓ

Source: After Anonymous, 1986. How to save water: a handbook for the householder, National Building Research Institute, CSIR, Pretoria, 20 p.

(ii) Morris, S.S., 1971. The role of water in urban communities, South African Journal of Science, VOL 67(3), p. 73 - 85., suggested that household water consumption could be subdivided as follows (assuming a mean daily consumption of 182 ℓ capita^{-1}): cooking (2% of mean daily per capita consumption); washing of clothing, dishes and other items (18%); personal hygiene (24%); general cleaning (3%); toilet (27%); physiological needs (1%), and recreation plus gardening (25% of mean daily per capita consumption). According to Morris, industry in the larger urban areas of South Africa uses some 12 - 15% of total urban consumption, or 45 - 68 ℓ capita^{-1} day^{-1}. Domestic demand accounts for approximately 60% of total consumption, where some 10 - 15% of the total urban consumption per se is used for household gardening purposes, with swimming pools responsible for approximately 0,1 - 0,3% of total urban consumption.

(iii) Numerous factors influence household water consumption. These are family size and age/sex composition; culture; diet; technological level (including the number of taps on the property); the availability of alternative supplies - such as boreholes, and income. Other factors are educational standing; social activities; the cost of water (including individual or bulk metering - Malan 1988)*; water losses through leaks, and size of land holding and type of garden (if any). Seasonal and climatic parameters (such as evapotranspiration) are of primary significance. Variability in weather conditions (especially rain) is responsible for short term fluctuations. Gebhardt (1975)** stressed the importance of excessive water pressure as a factor influencing consumption, where higher pressures result in higher consumption levels - especially in terms of garden watering, but also with reference to leaks in the reticulation system. Gebhardt found that minor water restrictions imposed on the use of garden sprinklers during a dry period reduced overall daily consumption (at peak demand) by some 20%, although a 33% reduction in supply pressure over 24 hours would have achieved the same result. Gebhardt

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* See Malan, G.J., 1988. Water consumption and possible water savings in apartment buildings, WRC Report No. 177/1/88, Water Research Commission, Pretoria, 24 p.

** See Gebhardt, D.S., 1975. The effects of pressure on domestic water supply including observations on the effect of limited garden-watering restrictions during a period of high demand, Water SA, VOL 1(1), p. 3 - 8. See also, Mason, S.J. and Joubert, A.M., 1995. A note on the inter-annual rainfall variability and water demand in the Johannesburg region, Water SA, VOL 21(3), p. 269 - 270.

(1970)* however, noted that water consumption in white-occupied flats in Johannesburg with bulk meters only, was similar to white household consumption (the absence of gardens in flats notwithstanding). Gebhardt observed that increases in domestic water demand reflect population growth but more importantly, rising standards of living.

(iv) A drastic reduction in water consumption (of the order of 50%) in the Durban-Pietermaritzburg Metropolitan Area was achieved during the drought of the early 1980s, when a household limit of 400 ℓ day^{-1} (assuming a per capita consumption of 100 ℓ day^{-1}), was imposed. Persistent culprits using more than 400 ℓ on a daily basis were disciplined through the fitting of restriction washers. A major law office in Pietermaritzburg was one high-profile offender - much to the great delight of many citizens of Pietermaritzburg (such was the prevailing sentiment), who carefully observed the restrictions and for whom newspaper reports and photographs of desperately low water levels in the Henley and Midmar dams, foretold disaster. Considerable cunning was displayed by a few technically-minded householders who managed to disconnect and then turn back their municipal flow meters to reflect reduced consumption; and by those who connected garden hosepipes to taps in adjacent properties at night. Some thrilling nocturnal chases and "ambushes" occasionally ensued**.

(v) According to Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages, the annual growth in domestic and industrial water demand averages approximately 4,4% for the large metropolitan areas in South Africa. A major demand sector however, is irrigation (and stock watering) which uses some 51,5% of the total volume of water consumed in South Africa. South Africa currently has approximately 1 200 000 ha of land under irrigation,

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* See Gebhardt, D.S., 1970. The influence of income on future domestic water consumption, Water Year 1970, Convention on Water for the Future, [Department of Water Affairs], 16 - 20 November 1970, Pretoria, 7 p. (The fixing of water tariffs requires careful thought. A trade-off is often required between unnecessary subsidization of high income households and a tariff which is excessive for low income households. Importantly, low income households spend proportionately more of their disposable income on basic foodstuffs (including water), than high income households. A system of progressive tariffs is usually needed to overcome these difficulties).

** See Schlemmer, L., Stewart, G. and Whittles, J., 1989. The socio-economic effects of water restrictions on local authorities, selected industrial and commercial establishments and other private agencies, WRC Report No. 168/1/89, Water Research Commission, Pretoria, 406 p. + app., as well as Van Zyl, J.H. and Viljoen, M.F., 1987. Die sosio-ekonomiese gevolge van waterbeperkings op besproeiingsboerderye, mynbou, elektrisiteitsvoorsiening en die sentrale owerheid, WRC Report No. 167/1/87, Water Research Commission, Pretoria, 478 p., plus Simpson, G.C., 1992. Research into the effects of reduced water consumption on domestic sewer systems, WRC Report No. 199/1/92, Water Research Commission, Pretoria, 36 p. + app. See also, Viljoen, M.F. and Botha, S.J., 1994. Waterbeperkings Deel 1: 'n metodologie vir die bepaling van die totale finansiële gevolge, Water SA, VOL 20(4), p. 323 - 328., as well as Viljoen, M.F. and Botha, S.J., 1994. Waterbeperkings Deel 2: die totale finansiële gevolge vir gebruikers van Vaalrivierwater, Water SA, VOL 20(4), p. 329 - 332.

of which 45% is flood-irrigated, with a further 12,5% under micro-irrigation (Anonymous, 1994)*. A new irrigation policy for South Africa, which will assist in the optimum use of irrigation water, is presently under discussion**.

(vi) Much debate has centred on the timing of the ultimate water crisis in South Africa as a whole, namely, when overall demand will exceed overall supply (notwithstanding the impacts of droughts). Before such a situation is reached however, a water quality crisis will probably be evident, with insufficient freshwater available to dilute industrial effluents and agricultural return flows. The Commission of Enquiry into Water Matters (1970, quoted in Hattingh, 1979)*** suggested that the demand for water would outstrip the economically available supply by the turn of the century. Du Plessis and Van Robbroeck (1978, quoted in Hattingh, 1979) calculated that the annual growth rate in water demand was not as high as the estimated 7% bearing in mind technological supply and demand innovations such as desalination, recycling and water restrictions. Du Plessis and Van Robbroeck estimated the total volume of economically available water at 34 x $10^9 m^3 y^{-1}$ (as opposed to the 27 - 29 x $10^9 m^3 y^{-1}$ assumed earlier). In their calculations, Du Plessis and Van Robbroeck assumed that a consumption rate of 500 m^3 $capita^{-1}$ y^{-1} (1 370 ℓ $capita^{-1}$ day^{-1}) was not unrealistic, within the range 200 - 2 300 m^3 $capita^{-1}$ y^{-1} found in other countries. Assuming such a consumption rate, the demand for water will probably exceed the available supply around 2010 - based on an approximately 2,2% increase in population each year - with a total population of some 66 400 000 people by 2010. Other projections can also be found in the literature and the "cut-off" date is open to speculation. However, what is certain, is that the water crisis will strike in the first half of the next century. What is not clear is whether the crisis will be one of affordability (namely, financial constraints on the importation of water from elsewhere in Africa); or an absolute crisis (not enough water *per se*), or at best, insufficient water in economically important regions. These issues are discussed in Anonymous (1986 - above). (The findings and recommendations of the Commission of Enquiry into Water Matters are reproduced in Anonymous, 1986).

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* See Anonymous, 1994. SA op voorpunt met besproeiing, Agricultural News, 11 April 1994, p. 5.

** See Backeberg, G.R., Bembridge, T.J., Bennie, A.T.P., Groenewald, J.A., Hammes, P.S., Pullen, R.A. and Thompson, H., 1996. Policy proposal for irrigated agriculture in South Africa: discussion paper, WRC Report No. KV 96/96, Water Research Commission, Pretoria, 119 p.

*** See Hattingh, W.H.J., 1979. Suggestions for water research with regard to health aspects of potable water, Symposium on Health Aspects of Water Supplies, National Institute for Water Research and the Institute of Water Pollution Control (Southern African Branch), 15 November 1979, Pretoria, 18 p.

Table L4: Some per capita household consumption data for formal urban households in the Durban-Pietermaritzburg Metropolitan Axis.

Income group		High density	Medium density	Low density
Pietermaritzburg				
High	Suburb	-	Clarendon	Ferncliffe
	Population group		White	White
	Occupancy (per household)		4,0	4,0
	Mean daily consumption (ℓ capita^{-1})		360	360
Upper middle	Suburb	-	Mountain Rise	Clarendon
	Population group		Asian	White
	Occupancy (per household)		7,4	4,0
	Mean daily consumption (ℓ capita^{-1})		240	330
Middle	Suburb	Hayfields (duplexes)	Hayfields	-
	Population group	White	White	
	Occupancy (per household)	2,2	4,0	
	Mean daily consumption (ℓ capita^{-1})	185	230	
Lower middle	Suburb	Northdale	Bisley	-
	Population group	Asian	White	
	Occupancy (per household)	5,6	4,0	
	Mean daily consumption (ℓ capita^{-1})	130		
Lower	Suburb	Eastwood	Westgate	-
	Population group	Coloured	White	
	Occupancy (per household)	5,6	4,0	
	Mean daily consumption (ℓ capita^{-1})	90	125	
Durban				
High	Suburb	-	Durban North	Durban North
	Population group		White	White
	Occupancy (per household)		3,24	3,24

Table L4: Some per capita household consumption data for formal urban households in the Durban-Pietermaritzburg Metropolitan Axis (continued).

Income group		High density	Medium density	Low density
High (contd)	Mean daily consumption (ℓ capita^{-1})		360	360
Upper middle	Suburb	Berea (duplexes)	Silverglen	Durban North
	Population group	White	Asian	White
	Occupancy (per household)	2,19	8,4	3,24
	Mean daily consumption (ℓ capita^{-1})	200	235	310
Middle	Suburb	-	Glenwood	-
	Population group		White	
	Occupancy (per household)		3,24	
	Mean daily consumption (ℓ capita^{-1})		215	
Lower middle	Suburb	Flamingo Court Flats	Escombe	-
	Population group	White	White	
	Occupancy (per household)	2,49	4,0	
	Mean daily consumption (ℓ capita^{-1})	130	150	
Lower	Suburb	Chatsworth	-	-
	Population group	Coloured		
	Occupancy (per household)	7,38		
	Mean daily consumption (ℓ capita^{-1})	75		

Source: After Horne Glasson Partners, 1989. Water plan 2025, VOL 3, Umgeni Water, Pietermaritzburg, various pages.

Note:

(i) The data refer to a period of three months in 1988. Most (formal) local authorities in Natal/KwaZulu are able to provide water consumption data. The Horne Glasson report is a valuable water supply/demand case study for the old Umgeni Water supply area, and includes useful population projection data.

(ii) Horne Glasson Partners, 1989. Water plan 2025, VOL 2, Umgeni Water, Pietermaritzburg, various pages, suggested that a reduction in water demand due to densification amongst higher income groups was evident, where up to 20% of total household consumption in high income, low density areas was used for swimming pools and general garden maintenance.

(iii) Perold, R.P., 1957. B. Water supply on the farm. Water requirements for home and farmyard, In: Handbook for Farmers in South Africa, VOL 1: Agriculture and Related Services, Department of Agriculture, Pretoria, p. 527 - 529., put forward a design consumption figure of 114 ℓ capita^{-1} day^{-1} for white (rural) farm households (presumably including a form of septic tank system). Such a consumption is much the same as white lower income urban consumption.

(iv) Commercial sector water consumption in the Central Business District (CBD) of Pietermaritzburg accounted for an "effective" 11% of the total domestic consumption for the Pietermaritzburg reticulation network. This figure reflects the effective population served in the CBD, where limited residential occupation and therefore demand was evident (Horne Glasson Partners, 1989, VOL 2).

(v) Horne Glasson Partners (1989, VOL 2), found that industrial water consumption in the Umgeni Water supply area varied from 10 kℓ ha^{-1} day^{-1} for light dry industries, to as much as 540 kℓ ha^{-1} day^{-1} for intensive wet industries such as textiles and sugar mills. The mean weighted industrial water consumption for the study area was some 35 kℓ ha^{-1} day^{-1}. For design purposes, a mean of 100 workers per gross hectare of industrial land was assumed. Densities were found to vary from 60 - 120 workers per gross hectare for early-developing/space-extensive types of industry vis-a-vis smaller and more established industries respectively. Densities in excess of 200 workers per gross hectare were noted in centrally located high intensity industries in Durban (Horne Glasson Partners, 1989. Water plan 2025, VOL 1, Umgeni Water, Pietermaritzburg, various pages).

Table L5: Some water consumption data for the Clermont Township in the Durban Functional Region.

Site	Existing service	Mean rooms per stand (375 rooms on 35 stands and 280 rooms on 36 stands respectively for survey households)	Total consumption for survey sample (ℓ day^{-1})	Mean consumption for survey sample (ℓ stand^{-1} day^{-1})	Mean consumption for survey sample (ℓ room^{-1} day^{-1})
Households					
Reservoir zone R1 and R5	Water only	10,7	15 124	432	40
Reservoir zone R4	Sewerage and water	7,8	28 191	783	101
	Water only	-	-	-	40
Reservoir zone R1, R4 and R5	No water connection	-	-	-	40
Shops	Sewerage and water (8 stands)	-	-	1 624	-
	Water only (28 stands)	-	-	650	-
	No water (11 stands)	-	-	650	-
Schools	Sewerage and water	-	-	30 ℓ capita^{-1} day^{-1}	-
	Water only	-	-	12 ℓ capita^{-1} day^{-1}	-

<u>Source</u>: After Anonymous, 1988. Republic of South Africa, Department of Development Aid (on behalf of the South African Development Trust), Chief Directorate: Works, Directorates: Civil and Agricultural Engineering Services, Project No. Z790 Clermont: Pinetown District: Natal, revised report on water consumption and augmentation of storage capacity, J.C. Theron Burke and Isaac Inc., Westville, 20 p. + app.

<u>See also</u>: Palmer Development Group, 1994. Water and sanitation in urban areas: survey of on-site conditions, WRC Report No. 561/1/94, Water Research Commission, Pretoria, 63 p. + app. (The report provides data on water and sanitation conditions with reference to backyard shacks, in six townships in South Africa including Clermont).

<u>Note</u>: (i) Recent household or per capita water consumption data for formal and less formal households in black townships are extremely difficult

to obtain. Difficulties include leaks; the damaging of street standpipes (sometimes left gushing for long periods); the seasonal availability of alternative supplies such as springs and rainwater; the reuse of water, and the impossibility of establishing the actual (sleep-on-the-premises) population - given inter alia the construction of backyard shacks and accordingly, problems in determining the number of "households". Other factors are unauthorized connections; defective water meters; the virtual breakdown of services in many townships - and the real physical danger to service suppliers, meter readers, and maintenance crews in certain areas. The philosophy of "entitlement" where services are not paid for, although expectations exist that much improved services should nonetheless be provided, also complicates accurate measurements of household consumption.

With the possible exception of older data, many of the consumption figures provided in the engineering literature are "guesstimates" based on total water demand for the area, divided by the estimated population. (Demographic information may be seriously in error especially in the major urban areas subject to high in-migration and land invasion). It should be noted that water consumption from unmetered yard or street standpipes in several black townships has been found to be excessive with regard to actual needs*. It could be argued that water consumption in many high income households is also excessive in relation to actual (as opposed to perceived) needs. However, water in high income households is paid for, which is certainly not the case in many townships.

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* See Bekker, A.P., 1980. Need for control of water consumption in low income housing projects - a technical report, Paper No. 19, Seminar on Water Supply and Drainage Services in Developing Countries, National Building Research Institute, CSIR, 30 September - 2 October 1980, Pretoria, 3 p., as well as Davis, A.B., 1980. Factors of bulk water supply and main sewerage for low cost housing schemes, Paper No. 15, Seminar on Water Supply and Drainage Services in Developing Countries, National Building Research Institute, CSIR, 30 September - 2 October 1980, Pretoria, 11 p. See in addition: Du Plessis, P.A., 1980. Water and sewerage in urban black communities, Paper No. 14, Seminar on Water Supply and Drainage Services in Developing Countries, National Building Research Institute, CSIR, 30 September - 2 October 1980, Pretoria, 3 p., and Uys, W.J., 1980. Water supply in the national states of South Africa, Paper No. 13, Seminar on Water Supply and Drainage Services in Developing Countries, National Building Research Institute, CSIR, 30 September - 2 October 1980, Pretoria, 7 p. (Other papers presented at the seminar are also highly relevant). Uys (1980) found that mean daily water consumption in the period 1967 - 1973, increased from 570 - 737 ℓ per stand in KwaMashu (metered connections) - probably reflecting higher standards of living as well as increased household numbers due to in-migration. In the same period, mean daily water consumption for Umlazi increased from 1 060 - 1 420 ℓ per stand indicative of (in reality), unmetered conditions. By 1975, mean daily water consumption in Umlazi had reached 1 757 ℓ per stand (Davis, 1980), whereupon numerous meters were installed (in 1976). Consumption declined in the interim, rising again (although at a slower rate) in 1978 when reading of the installed meters commenced. Davis observed however, that difficulties were encountered at that time with the reading of meters and the collection of monies, which effectively resulted in higher consumption. (It should be noted for comparative purposes, that the design stand consumption was 1 136 ℓ day^{-1}). Excessive water consumption (whether due to leaks and/or the waste of water), can have important design and financial implications for required extensions to water and sanitation systems. In semi-arid areas, the wastage of water by urban residents can result in a denial of water to other potential or existing consumers, either in terms of water per se, or due to budgetary constraints for the necessary infrastructure.

(ii) The Clermont household data refer to a sample of formal and less formal dwellings. A mean occupancy of two people per room was found in the survey, which implies a mean daily per capita (household) water consumption of approximately 28 ℓ (based on individual sample stand data). The data however, refer more specifically to daily consumption per room and per stand, and not per capita. The consumption data for shops do not include attached rooms. An overall estimate (excluding the number of rooms), was provided for schools. Survey data showed that the mean number of rooms per stand in sewered areas was 30% less than in non-sewered areas. The mean daily consumption per room in sewered areas was some 2,5 times higher than in non-sewered areas, reflecting a higher standard of living. The mean number of rooms per stand (all types of dwellings) was 9,6. On an holistic basis, consumption for sample stands connected to water only, averaged a very low 384 ℓ day^{-1}, with a more realistic 970 ℓ day^{-1} for fully serviced plots. Considerable differences in consumption were evident where bulk water volumes supplied to reservoirs were used as the basis for consumption calculations. For example, daily (household) per capita consumption based on reservoir data was 65 ℓ, with a figure of 130 ℓ per room, or a very high figure of 1 250 ℓ per stand (formal and less formal dwellings). Similar discrepancies have been found in many black townships in Natal/KwaZulu. Bosch and Associates of Durban (quoted in the J.C. Theron Burke and Isaac report), in a study of Umlazi, observed that only one third of the bulk water supplied was registered as being consumed. Differences were mainly ascribed to leaks, with faulty water meters and the incorrect reading thereof also apparent. Revenue losses are due to non-payment or sporadic payment only. Even where payment is undertaken on a regular basis, the monies collected may not reflect true consumption (as explained above). Calls therefore for upgraded services whereupon regular payment will commence, may to some extent backfire since meters will be repaired and properly monitored - assuming that conventional metering is the most suitable payment option*. Equity should result where major leaks are repaired and the payment load across the whole township is uniformly applied**. It follows that increased delivery efficiency, proper billing procedures and accessible payment points are essential.

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* Prepayment (as already undertaken for electricity), is a possibility. See, Simes, C.E., Lings, R.J. and Tshivhase, T., 1994. Prepayment water metering for South Africa, WRC Report No. KV 56/94, Water Research Commission, Pretoria, 26 p.

** A popular (although alarming) overview of the extent of the services debt of many black townships in South Africa, and possible consequences, is the following: Brink, A., 1994. The freebie timebomb, You, No. 376, 29 December 1994, p. 80 - 81. It is to be sincerely hoped that the Masakhane campaign (discussed later in the chapter) is successful. See also, Rogerson, C.M., 1996. Willingness to pay for water: the international debates, Water SA, VOL 22(4), p. 373 - 380.

(iii) Horne Glasson Partners envisaged the phased introduction of three levels of service (up to the year 2025), with respect to black formal and informal township dwellings in the old Umgeni Water supply area (including Clermont). The relevant data (allowing for up to 20% losses within the supply system) are presented below:

Service level	Black formal dwellings with waterborne sanitation	Black informal dwellings with <u>in situ</u> sanitation
1	Full service 75 ℓ capita^{-1} day^{-1}	25 ℓ capita^{-1} day^{-1} (standpipes at 200 m intervals)
2	Full service 120 ℓ capita^{-1} day^{-1}	50 ℓ capita^{-1} day^{-1} (one standpipe per plot)
3	Full service 75 - 235 ℓ capita^{-1} day^{-1} (depending on rising income)	50 ℓ capita^{-1} day^{-1} (one standpipe per plot)

<u>Source</u>: After Horne Glasson Partners, 1989. Water plan 2025, VOL 2, Umgeni Water, Pietermaritzburg, various pages. (The authors observed that under certain scenario conditions - see (iv) below - a design consumption of 120 ℓ capita^{-1} day^{-1} (full service level 2) might constitute an overestimate, where a more realistic figure would be of the order of 80 - 95 ℓ capita^{-1} day^{-1} with regard to expected standards of living. However, if high economic prosperity is evident in the future (after 2005), then a design consumption of 120 ℓ capita^{-1} day^{-1} would not meet the actual demand resulting from a considerable increase in living standards. A minimum service of 50 ℓ capita^{-1} day^{-1} for formal dwellings and 25 ℓ capita^{-1} day^{-1} for informal dwellings was suggested for the old Umgeni Water supply area. This was regarded as the most basic requirement which should be maintained, for example, during drought periods).

(iv) A few water demand projections for Natal/KwaZulu (published prior to the 1994 general elections) made reference to political and socio-economic scenarios, as primary planning factors. Horne Glasson Partners of Durban, for instance, referred to a "status quo" scenario, an "emergent trends" scenario and a "high road" scenario*. Both industrial and domestic water requirements are important in scenario planning. In the latter case, special emphasis was placed on the domestic water needs of the rapidly urbanizing black population, mainly in the Durban-Pietermaritzburg Metropolitan Area. Despite obvious changes following the general elections, scenario planning (as a technique) is still relevant.

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* See Horne Glasson Partners, 1989. Water plan 2025, VOL 1 - 3, various pages, Umgeni Water, Pietermaritzburg. (The document is being revised to reflect the supply and demand situation up to the year 2030). See also, Spies, P.H., 1986. Perspectives on the future of Natal/KwaZulu, Natal Town and Regional Planning Commission Report, VOL 69, Pietermaritzburg, 149 p., as well as Sunter, C., 1987. <u>The World and South Africa in the 1990s</u>, Human and Rousseau, and Tafelberg, Cape Town, 111 p., plus Sunter, C., 1992. <u>The New Century: Quest for the High Road</u>, Human and Rousseau, and Tafelberg, Cape Town, 187 p. (It should be borne in mind that the Institute for Futures Research, University of Stellenbosch, Private Bag X1, Matieland, 7602, has considerable expertise in terms of scenario development).

(v) Alcock, P., 1986. An examination of household water consumption in the Inadi Ward, KwaZulu, Civil Engineer in South Africa, VOL 28(11), p. 424 - 426., provided overview water consumption data for various black townships in southern Africa. Broad planning and water demand data (on a regional basis), are presented in Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages, as well as in Horne Glasson Partners (1989 - above). In similar vein, see: Emmett, T. and Rakgoadi, S., 1993. Water supply and sanitation services in South Africa, Project for Statistics on Living Standards and Development, Southern Africa Labour and Development Research Unit, University of Cape Town, Rondebosch, 218 p. + app., as well as Palmer, I. and Eberhard, R., 1994. Evaluation of water supply to developing urban communities in South Africa, Phase 1 - overview, WRC Report No. KV 49/94, Water Research Commission, Pretoria, various pages. (The latter two publications contain useful regional water demand data for black settled areas in South Africa, with special reference to urbanized communities).

(vi) Interesting (historical) incremental water consumption data for rural American (farm) households were provided by Kains, M.G., 1973. Five Acres and Independence: a Practical Guide to the Selection and Management of the Small Farm, New American Library, New York, 401 p. The design consumption data are given below. The data have relevance for the upgrading of services in black informal and some formal settlements.

Supply situation	Design consumption (ℓ capita^{-1} day^{-1})
Water carried to the household	30
Pump at kitchen sink	38
Tap at kitchen sink	45
Running hot and cold water in the kitchen	68
Complete plumbing with water under pressure (including some form of septic tank system)	114

Table L6: Some typical domestic water consumption data for black households in South Africa.

Source	Range in mean daily water consumption (ℓ capita^{-1})
River, dam, spring, well, borehole, street standpipe and kiosk (250 m - 3 km to source)	9 - 50
Standpipe in yard or one tap in household (no waterborne sanitation)	30 - 80
Multiple tap households (unmetered and metered) including some waterborne sanitation	180 - 300

Source: Fieldwork.

See also:

(i) Alcock, P.G., 1987. Domestic water supplies in non-urban KwaZulu: existing water systems, Occasional Publication No. 8, Department of Crop Science, University of Natal, Pietermaritzburg, 100 p.

(ii) Alcock, P.G., 1989. Water supply systems for the Ximba Ward of KwaZulu: a proposed strategy, Occasional Publication No. 9, Department of Crop Science, University of Natal, Pietermaritzburg, 128 p.

(iii) Division of Water Technology, CSIR, 1993. Part 1: Guidelines on the cost effectiveness of rural water supply and sanitation projects, 35 p. Part 2: Guidelines on the technology for and management of rural water supply and sanitation projects, 191 p. + app., WRC Report No. 231/1/93, Water Research Commission, Pretoria.

(iv) Feachem, R., Burns, E., Cairncross, S., Cronin, A., Cross, P., Curtis, D., Khalid Khan, M., Lamb, D. and Southall, H., 1978. Water, Health and Development: an Interdisciplinary Evaluation, Tri-Med Books, London, 267 p.

(v) Van Schalkwyk, A., 1996. Guidelines for the estimation of domestic water demand of developing communities in the northern Transvaal, WRC Report No. 480/1/96, Water Research Commission, Pretoria, 113 p.

Note:

(i) A considerable range in consumption data can be found in the South African literature. The above table provides an estimate of the overall consumption pattern (excluding extreme scenarios).

(ii) Daily consumption in rural and peri-urban areas, where water must be fetched from a distant external source and carried back to the household in 20 or 25 ℓ containers - balanced on the head or placed in a wheelbarrow - tends to be at a minimum or subsistence level. Several factors influence daily per capita or household consumption including the type of settlement; the number of family members available to collect water; the return of weekly-migrant family members over weekends (resulting in a much higher demand for water); the distance and type of terrain to be walked, and the perceived quality of the water source. Other factors are the household water storage capacity (including provision for rainwater collection and storage); the preferred site for laundry operations; payment or non-payment for water, and weather conditions. There is little seasonal variation in demand under such circumstances, although fieldwork suggests that the availability of roof-runoff in households with large rainwater storage systems, will tend to reduce consumption from external sources in summer (Alcock, 1989 - above). A similar trend has been found in peri-urban KwaZulu in areas supplied by public standpipes. A marked reuse of water is evident generally, depending on distance to source or payment for water. Considerable use is made of free sources such as springs and rivers for clothes washing purposes, if water has to be purchased in peri-urban and urban areas. As would be expected in rural and peri-urban areas where raw water only is available, the nearest source of water is generally preferred (provided that water quality - for potable purposes - is regarded as good). Kruger (1982)* in a study of rural villages in the Transkei (with boreholes or protected springs and gravity reticulation to standpipes), found that a desired return journey of 500 m was evident, beyond which, residents used other sources. Friedman (1985, quoted in Mann, 1985)**, working in the Valley Trust area in the Durban Functional Region, observed that most return journeys to preferred water sources involved a distance of less than 1 km (which would probably take about 20 minutes).

(iii) In situations where a standpipe is available in or immediately adjacent to the yard, consumption may increase by a factor of two or three, in comparison with more distant sources of supply. Multiple tap households (even without waterborne sanitation), as opposed to single tap households, will use substantially more water depending on circumstances such as metering and the watering of gardens. Expressed in a different manner, water which must be carried some distance is used with a much more strict accounting than water which is available closer to the home.

(iv) Alcock (1986)*** in a survey of the Inadi Ward, Vulindlela District (KwaZulu) in the vicinity of Henley Dam near Pietermaritzburg, found a weighted mean daily household consumption of 91,5 ℓ for water consumed <u>at the home</u> (mainly with reference to springs). The weighted mean daily per capita consumption for water consumed at the home was 15,6 ℓ. The data

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* Kruger, P., 1982. Personal communication, O'Connell Manthé and Partners, Durban.

** See Mann, C., 1985. The Valley Trust water and sanitation projects, Valley Trust, Botha's Hill, 48 p.

*** See Alcock, P., 1986. An examination of household water consumption in the Inadi Ward, KwaZulu, <u>Civil Engineer in South Africa</u>, VOL 28(11), p. 424 - 426.

are in agreement with consumption figures for the Valley Trust area. An (overall) bimodal daily water demand pattern is generally evident at water sources in rural and peri-urban KwaZulu, with peaks in the early morning and early-mid afternoon (where water is available some distance from the household). An average of three water collecting trips per day is undertaken by rural and peri-urban households, which may involve up to three hours (or more) in total. Longer periods of daylight result in withdrawals beginning earlier and ending later in the day. Water is not fetched at night. Of the per capita consumption of 15,6 ℓ day^{-1}, probably up to 5 ℓ day^{-1} is used for cooking and food preparation, with up to 8 ℓ day^{-1} being used for all washing purposes (bearing in mind the reuse of water). The balance is used for drinking needs. In terms of drought planning, a minimum supply of 15 ℓ $capita^{-1}$ day^{-1} at a 100% assurance level (for <u>all</u> requirements) has been suggested for rural households (Maaren, 1993)*. The World Health Organization recommended a design minimum of 50 ℓ $capita^{-1}$ day^{-1} with a (reasonable access) distance to a standpipe of 200 m in urban areas. In the Transkei, a design criterion of 35 - 50 ℓ $capita^{-1}$ day^{-1} was adopted for reticulated supplies in rural villages (Kruger, 1982 - above). Feachem <u>et al</u> (1978 - above) recommended a design supply of 30 ℓ $capita^{-1}$ day^{-1} for rural areas in Lesotho, which would apply for a decade. Alcock (1984)** suggested a design consumption of 25 ℓ $capita^{-1}$ day^{-1} for the Inadi Ward, for the period 1982 - 1992.

Few data are available on the number of households or individuals usually dependent on a given external water source in rural and peri-urban KwaZulu. Alcock (1987 and 1989 - above) recorded the following dependency ratios (including standpipes and kiosks in the Durban Functional Region):

* See Maaren, H., 1993. Low-flow hydrology workshop: proceedings, Water Research Commission, Pretoria, 16 p.

** See Alcock, P.G., 1984. A water supply strategy for the Inadi Ward, Vulindlela District, KwaZulu, M.Sc. Thesis, Department of Geography, University of South Africa, Pretoria, 214 p.

Supply source and consumer	Minimum	Mean	Maximum
Perennial springs (households)	-	23	50
Tube wells with bucket pumps (households)	-	10	23
Boreholes with handpumps (households)*	48	66	127
Public standpipes (individuals)	-	-	300 (estimated)
Kiosks (households)	10	171	372

(v) In terms of drinking water consumption in South Africa, Bourne, Bourne, Watermeyer and Klopper (1987)** in a study of Cape Town residents, found a mean total daily per capita water intake (tap water and water in commercial beverages as well as water bound in liquid and solid food), of 2,19 ℓ for whites and 1,26 ℓ for Coloureds; or 1,77 ℓ on an overall basis (Bourne, Bourne and Hattingh, 1989)***. Consumption was higher in summer than during winter. The ratio of tap water consumed at home to total liquid consumed was approximately 0,5. Alcock (1986 - above) in the survey of the Inadi Ward, KwaZulu, determined a weighted per capita drinking water consumption - excluding bottled beverages and liquor, milk and traditional liquor - averaging 2,3 ℓ day^{-1}, or some 15% of the water used at the household. It has been accepted for design purposes that a 70 kg man will consume 2 ℓ of water day^{-1},

* See Daphne, P., 1985. A study of the impact of donated boreholes in the Mpukunyoni area of Natal/KwaZulu, Publication Series E No. 2, Centre for Social Research and Documentation, University of Zululand, KwaDlangezwa, 14 p. (It should be noted that Alcock (1989 - above) calculated a dependency ratio of some 60 - 100 households per borehole fitted with a handpump, based on a time analysis in the Ximba Ward, near Nagle Dam. The variability depends on the proportion of daily household water requirements drawn from the given borehole. If potable needs only are satisfied, then a borehole can supply considerably more households on a daily basis - assuming a 12 hour withdrawal period. The KwaZulu Department of Agriculture and Forestry uses a dependency ratio of 100 households per borehole. See also, Hatting[h], P.S., 1972. Water supply in Bantu homelands, Journal of Racial Affairs, VOL 23(2), p. 78 - 90).

** See Bourne, L.T., Bourne, D.E., Watermeyer, G.S. and Klopper, J.M.L., 1987. A liquid consumption survey of individuals in Greater Cape Town, WRC Report No. 74/2/87, Water Research Commission, Pretoria, 162 p.

*** See Bourne, L.T., Bourne, D.E. and Hattingh, W.H.J., 1989. Boiled and unboiled tap water intake of Cape Town residents, Water SA, VOL 15(4), p. 227 - 230.

excluding solid food (World Health Organization, 1984, quoted in Bourne, Bourne and Hattingh, 1989). This figure can vary somewhat depending on occupation, climate, body mass and individual physiology*. Several factors influencing human water needs are discussed by Strydom, Van Graan and Holdsworth (1965)**. An accurate assessment of potable requirements has important implications for the calculation of exposure risk to compounds in water (see the beginning of the chapter on water quality).

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* According to Lafontaine (1985, quoted in Bourne, Bourne, Watermeyer and Klopper, 1987 - above), the daily water requirement of adults, adolescents and large children in the normal conditions of a moderate climate, is approximately 35 - 50 g of water per kilogram of body mass (increasing during pregnancy and lactation as well as in a tropical climate, or during work in high temperatures). The daily needs of infants are proportionately much higher, ranging from 100 - 150 g of water per kilogram of body mass (or three times that of an adult). Lafontaine (1975, also quoted in the above publication), found that water is lost from the body in a 24 hour cycle (data presumably for adults), via urination (approximately 1,0 - 1,5 ℓ); through bowel movements (some 0,14 ℓ); through the lungs (0,3 - 0,4 ℓ); through the skin as (passive process) perspiration (0,6 - 0,8 ℓ), and as (active process) sweating (0 - 1,5 ℓ depending on circumstances). Newburgh and MacKinnon (1934, quoted in Bourne, Bourne, Watermeyer and Klopper, 1987) observed that generally, a total of 2 - 3 ℓ of water is lost daily, and possibly more under certain conditions. The 24 hour water requirement is accordingly that volume which replaces losses, where thirst is an accurate guide to the volume of water needed. It should be borne in mind that some 0,2 - 0,4 ℓ of water is formed during food combustion.

** See Strydom, N.B., Van Graan, C.H. and Holdsworth, L.D., 1965. The water requirements of humans, <u>Journal of Occupational Medicine</u>, VOL 7(11), p. 581 - 587.

Table L7: Some South African industrial water consumption data including wastewater quality information.

<table>
<tr><th>Industry</th><th colspan="3">Details</th></tr>
<tr><td>Soft drinks and carbonated waters industry</td><td colspan="3">The numerous carbonated soft drink bottling and canning plants, dairies and fruit juice packaging plants in South Africa, produce some 1,5 x $10^6 m^3$ of soft drink on an annual basis. Fruit juice plants and dairies are responsible for 5% and 10% of the total volume respectively, with the balance produced by the carbonated soft drink bottling and canning plants. A total annual consumption of approximately 4,0 x $10^6 m^3$ of water, of which 50 - 80% is discharged as wastewater, was evident. The mean SWI (Specific Water Intake) was 2,7 m^3 of water per m^3 of soft drink, with a recommended target SWI of 2,3 m^3 of water per m^3 of soft drink produced. The mean SPL (Specific Pollution Load) was 4,0 kg COD (Chemical Oxygen Demand) per m^3 of soft drink, with a suggested target SPL for untreated wastewater of 3,5 kg COD per m^3 of soft drink. A target of 5 kg total dissolved solids (salts) per m^3 of soft drink for plants with bottle washers, and a target of 1,5 kg total dissolved solids per m^3 of soft drink for plants without bottle washers, was suggested</td></tr>
<tr><td rowspan="5">Dairy industry</td><td colspan="3">Over 150 dairies in South Africa consume approximately 4,6 x $10^6 m^3$ of water annually, of which 75 - 95% is discharged as wastewater. The relevant data are summarized below:</td></tr>
<tr><td>Category</td><td>SWI
(volume/volume unless otherwise indicated)</td><td>Target SWI</td></tr>
<tr><td>Pasteurised milk
(bulk production)</td><td>1,6*</td><td>0,75*</td></tr>
<tr><td>Pasteurised milk packed in
- sachets
- cartons
- bottles</td><td>
1,7*
2,2*
3,0*</td><td>
1,1*
1,5*
2,0*</td></tr>
<tr><td>Other milk products in cartons or plastic tubs
- cultured products
- fruit juices and mixes
- sterilized/UHT products
- skim milk</td><td>

10,2
2,7
3,7
3,6*</td><td>

6,3
1,7
2,0
2,1*</td></tr>
</table>

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details		
Dairy industry (continued)	Dry milk products - milk powder - cheese - butter - ice cream - condensed milk	 11,8 $m^3 t^{-1}$* 23,0 $m^3 t^{-1}$* 1,5 $m^3 t^{-1}$* 2,5 4,4 $m^3 t^{-1}$*	 8,7 $m^3 t^{-1}$* 20,0 $m^3 t^{-1}$* 1,3 $m^3 t^{-1}$* 1,9 3,5 $m^3 t^{-1}$*
	<u>Note</u>: An asterisk denotes items produced from raw milk, and the data include water consumed in the reception stage. Data without an asterisk refer to products derived from intermediate materials. The reception function was examined separately and a specific water usage of 0,6 volume/volume was determined for reception only, with a proposed target of 0,4 volume/volume (based on the volume of raw milk received) Most of the water consumed in the dairy industry is for cleaning operations. In this regard, the use of plastic sachets rather than bottles was suggested, which would result in a considerable reduction in water consumption, as well as a reduction in wastewater volumes and pollutant loads		
Malt brewing industry	In 1986 there were eight malt beer breweries in South Africa, which produced approximately 1,2 x $10^6 m^3$ of beer annually. Total annual water consumption was some 8,7 x $10^6 m^3$, with 65 - 70% of the water consumed, being discharged as wastewater. The SWI varied between 5,5 - 8,8 m^3 of water per m^3 of beer produced. A target SWI of 6 m^3 of water per m^3 of beer for existing breweries, and 5 m^3 of water per m^3 of beer for new breweries was suggested. The SPL was found to vary between 10,4 - 20,0 kg COD per m^3 of beer produced. The target SPL for untreated wastewater was recommended as 10 kg COD per m^3 of beer produced for existing breweries, and 7,5 kg COD per m^3 of beer produced for new breweries		

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details
Sorghum malt and beer industry	Thirty-three sorghum breweries are found in South Africa producing 1,1 x $10^6 m^3$ of beer each year, with an annual water consumption of 2,75 x $10^6 m^3$. Sorghum maltsters annually produce some 185 400 t of malt, consuming approximately 630 000 m^3 of water. The mean SWI was 3,4 m^3 of water per tonne of malt, and 2,5 m^3 of water per m^3 of beer produced. A target SWI of 3,0 m^3 of water per tonne (for large or mechanized maltsters); 7,0 m^3 of water per tonne for small maltsters (with a monthly production of less than 300 t), and 2,0 m^3 of water per m^3 of beer for breweries, was recommended. Wastewater volumes discharged for brewing and malting were 52% and 84% of the total water intake respectively. The SPL was determined as 8,6 kg COD per tonne of malt and 5,2 kg COD per m^3 of beer produced. A target SPL of 7,0 kg COD per tonne of malt and 5,0 kg COD per m^3 of beer produced, was suggested
Wine industry	The South African wine industry consists of several industrial operations mainly involved with the processing of grapes to a variety of alcoholic and non-alcoholic products. The data below refer primarily to plants which use considerable volumes of water. Some 1,0 x 10^6 t of grapes are produced annually in South Africa. Most of the crop is fermented to produce approximately 0,9 x $10^6 m^3$ of wine on an annual basis, of which some 60% is subsequently distilled to spirit products. The SWI in wine making operations varied from 700 - 3 800 ℓ per tonne of grapes (or 800 - 4 400 ℓ per m^3 of wine processed). Most of the water is used for cellar cooling and to wash the floors and equipment. For spirit distillation, SWI values ranged from 1,8 - 6,2 ℓ per litre of absolute alcohol produced, where most of the water is used to raise steam, for cooling purposes, and to wash floors and equipment. The SWI variability reflects the scale or size of the particular operation as well as the range of activities at the plant, and the method of bottling and packaging used. SPL values for wine making varied from 1,7 - 5,6 kg COD per tonne, and 95 - 145 kg COD per tonne for spirit distillation. Solid wastes mainly concern the pips and skins of the grapes, where one tonne of harvested grapes generates approximately 0,11 tonnes of solid waste which is returned to the land

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details
Edible oils industry	Sixteen edible oil processing plants in South Africa produce some 250 000 t of edible oil each year, with an annual consumption of approximately 1,5 x $10^6 m^3$ of water. The SWI varied between 2,1 - 3,1 m^3 of water per tonne for milling, and 3,2 - 4,6 m^3 of water per tonne for refining. A target SWI of 2,0 m^3 of water per tonne for milling, and 3,0 m^3 of water per tonne for refining was suggested. A target SWI of 5,0 m^3 of water per tonne for a plant milling and refining all product oil on site, was recommended. The SPL ranged from 4,3 - 13,8 kg COD per tonne of oil and 10,1 - 24,8 kg total dissolved solids per tonne of oil. A target SPL of 7,0 kg COD per tonne of oil and 12,0 kg total dissolved solids per tonne of oil was suggested, for a plant milling and refining all product oil on site
Red meat industry	A total of 285 red meat abattoirs in South Africa slaughter some 11 x 10^6 animals and consume 5,8 x $10^6 m^3$ of water on an annual basis. Wastewater volumes generally constitute 80 - 85% of the water intake, with an annual wastewater discharge for the industry as a whole, of some 4,9 x $10^6 m^3$. The mean SWI was 1,36 m^3 of water per Water Related Cattle Unit (WRCU) for A grade abattoirs, and 2,04 m^3 of water per WRCU for other grade abattoirs. A target SWI of 1,1 m^3 of water per WRCU for A grade abattoirs and 1,75 m^3 of water per WRCU for other grade abattoirs was suggested. The mean SPL for A grade abattoirs was 5,2 kg COD per WRCU and 1,6 kg suspended solids per WRCU. For other grade abattoirs, the mean SPL was 8,5 kg COD per WRCU and 1,4 kg suspended solids per WRCU. A target SPL of 4,0 kg COD per WRCU and 1,0 kg suspended solids per WRCU for A grade abattoirs, as well as 5,0 kg COD per WRCU and 1,0 kg suspended solids per WRCU for other grade abattoirs, was recommended
White meat industry	A total of 140 poultry abattoirs operate in South Africa, slaughtering some 330 x 10^6 birds on an annual basis. The annual water consumption is of the order of 6,0 x $10^6 m^3$. The weighted mean SWI was 17 ℓ per bird for AP grade abattoirs, and 20 ℓ per bird for other poultry abattoirs (within a range of 15 - 20 ℓ per bird for AP grade abattoirs and 15 - 30 ℓ per bird for other grade abattoirs). A target SWI of 15 ℓ per bird (for AP grade abattoirs) and 20 ℓ per bird for other grade abattoirs was recommended. The weighted mean SPL was 29 g COD per bird and 7 g suspended solids per bird for AP grade abattoirs, and 64 g COD per bird and 14 g suspended solids per bird for other grade abattoirs. A target SPL of 29 g COD per bird and 7 g suspended solids per bird for AP grade abattoirs was suggested. A target SPL for other grade abattoirs of 64 g COD per bird and 14 g suspended solids per bird was recommended

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details
Tanning and leather finishing industry	Twenty tanneries are found in South Africa, which together process approximately 2 x 10^6 hides every year. Annual water consumption is some 600 000 m^3, nearly all of which is discharged as wastewater. A mean full tanning SWI of 432 ℓ per hide (within the range 320 - 744 ℓ per hide) was found. A target SWI of 430 ℓ per hide was proposed. The SPL varied between 0,9 - 6,8 kg COD per hide (mean of 3,7 kg COD per hide); 2,6 - 8,9 kg total dissolved solids per hide (mean of 7,7 kg total dissolved solids per hide); 0,5 - 1,4 kg suspended solids per hide (mean of 0,8 kg suspended solids per hide), and 0,01 - 0,2 kg chromium per hide (mean of 0,1 kg chromium per hide). A target SPL of 1,0 kg COD per hide, 3,0 kg total dissolved solids per hide, 0,5 kg suspended solids per hide, and less than 0,01 kg chromium per hide, has been proposed. Problems are evident with the economic purification of wastewater from tanneries, where the technology for treatment to effluent standards is not available
Sugar industry	There are 16 sugar cane processing plants and one refinery in South Africa, which together produce approximately 12,0 x 10^6 t of sugar per annum (1985 data). Of the 16 processing plants, 10 are mills only, and six are mills with an attached "back-end" refinery (the latter situation is assuming increased importance in the sugar industry). Sugar cane consists largely of water (70% by mass), where the industrial process involves extracting sugar crystals from a solution. Accordingly, most of the water in the sugar cane as well as the plant water intake is evaporated and can be recovered as condensate. The SWI varied from 30 - 100 m^3 per 100 tonnes of sugar cane processed, with a mean SWI of 60 m^3 per 100 tonnes of cane processed. Wastewater volumes (given the nature of the manufacturing technique) are fairly small (some 30% of the water intake), or approximately 750 - 1 500 m^3 on a daily basis. The COD of wastewater generally varies between 1 500 - 2 000 mg ℓ^{-1} (due mainly to sugar lost in washing, and as a result of cooling-water overflows). Problems are evident with sugar plant wastewaters, since the COD load is almost totally soluble, leading to sludge bulking and sludge loss problems in conventional biological treatment works. Solid wastes include boiler ash and smuts which are disposed of as landfill, as well as filter cake from the milling process which can be used as fertilizer

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details
Pulp and paper industry	Twenty-one mill sites are found in South Africa, ranging from small household-tissue mills to advanced integrated pulp and paper mills. The industry collectively produces some 3,0 x 10^6 t of pulp and paper products each year. The SWI varied from 33 - 136 m^3 per tonne for integrated pulp and paper mills, and between 1 - 49 m^3 per tonne for pulp and paper products plants. The SPL varied between 9 - 80 kg COD per tonne and 23 - 183 kg total dissolved solids per tonne for integrated pulp and paper mills, and between 4 - 10 kg COD per tonne and 2 - 110 kg total dissolved solids per tonne for non-integrated plants. The tree species or pulp material used, as well as the efficiency of the mill (in terms of process control and operation), the paper produced, and the degree of chemical recovery on wastewater treatment prior to discharge, all influence the water intake and wastewater quality. Several well-reported effluent spills (sometimes with significant fish deaths), as well as environmental pressure generally, have resulted in a reduction of water intake volumes and the pollution potential of pulp and paper mills. (For an older perspective see Myburgh, C.J., 1970. South African Pulp and Paper Industries Limited's approach to the water shortage and effluent disposal problem, Water Year 1970, Convention on Water for the Future, [Department of Water Affairs], 16 - 20 November 1970, Pretoria, 6 p.)
Textile industry	The textile industry consists of a group of related industrial operations which use natural and synthetic fibres to produce a wide variety of end products, ranging from processed fibres to finished garments. The data below refer to the industrial category which uses considerable volumes of water. The SWI varied from 94 - 400 ℓ per kg of material processed, reflecting the diverse nature of the industry, as well as the wastage of water at some plants. SPL values likewise, varied to a considerable extent depending on the process involved, which in turn is influenced by the material handled and the available equipment. In essence, textile industry wastewaters have a high salinity with a very variable pH. In some cases, a high (relatively non-biodegradable) organic content, as well as marked heavy metal concentrations and strong colour, are characteristic of the wastewater

Table L7: Some South African industrial water consumption data including wastewater quality information (continued).

Industry	Details
Laundries	Laundries in South Africa consume approximately 3,0 x $10^6 m^3$ of water annually, of which 95% is discharged as wastewater. The weighted mean SWI was 15,1 ℓ per kg of laundry washed. A wide range, namely, 8,0 - 58,4 ℓ per kg was evident. Laundries with a rinse-water recycle procedure had a SWI of approximately 9 ℓ per kg, while firms without a rinse-water recycle facility had a SWI of some 30 ℓ per kg. A target SWI of 8 ℓ per kg and 20 ℓ per kg was suggested for rinse-water recycling and non rinse-water recycling firms respectively. The weighted mean SPL was 8,8 g COD per kg; 19,8 g total dissolved solids per kg; 2,6 g suspended solids per kg, and 0,7 g ortho-phosphate (as P) per kg. A target SPL corresponding to these industry means was recommended for total dissolved solids and ortho-phosphate (as P), while no target SPL values were suggested for COD and suspended solids, which depend on the type of material to be washed
Metal finishing industry	Metal finishing covers a wide variety of techniques, where electroplating, anodizing and phosphating processes were found to be the most water intensive categories of the industry as a whole. The SWI varied between 0,03 - 1,25 m^3 of water per "effective" m^2 of surface treated. A target SWI of 0,1 m^3 of water per effective m^2 of surface treated for firms with a monthly production in excess of 10 000 m^2, and 0,2 m^3 of water per effective m^2 of surface treated (for firms with a monthly production of less than 10 000 m^2), was recommended. The SPL (based on total dissolved solids), was highly variable depending on the process concerned. Much of the pollution from metal finishing industries is caused by the dumping of process solutions (which should be examined in the first instance to reduce water pollution)

<u>Source</u>: After Steffen, Robertson and Kirsten Inc., 1991. National industrial water and waste-water survey, WRC Report No. 145/1/91, Water Research Commission, Pretoria, 26 p. + app.

<u>See also</u>: (i) Anonymous, 1989. Water supply guidelines for township development schemes in Johannesburg, Water and Gas Department, Johannesburg Corporation, Johannesburg, 21 p. + app. (Some brief water consumption data specific to the Johannesburg area, in terms of overall industrial consumption, are presented in the document).

(ii) Funke, J.W., 1969. Industrial water and effluent management: some aspects on conservation of water and effects of effluent disposal on the environment, Summerschool on Water Pollution and Water Reuse, Ref. No. W2/1/19/2, January 1969, University of Pretoria, Pretoria, 32 p. (The publication provides older water consumption data reflecting earlier production techniques for industries listed in the above table, as well as for the gold, steel and electricity generation industries. Consumptive use of water (total intake minus total return flow) data are also presented in the report). Similar (older) data can be found in Van Duuren, F.A. and Funke, J.W., 1970. Optimization of water use by means of water quality and volume requirements, Water Year 1970, Convention on Water for the Future, [Department of Water Affairs], 16 - 20 November 1970, Pretoria, 8 p. According to the Commission of Enquiry into Water Matters which reported in 1970, the volume of water consumed per electricity unit sent out (at that time) from power stations, varied from 0,006 m^3 per kWh in old power stations to 0,004 m^3 per kWh in modern stations (Anonymous, 1986)*. More recent innovations have reduced water consumption even further. Anonymous (1986) noted that the water consumption at the ISCOR Pretoria works was 5 m^3 per tonne of steel produced.

(iii) Funke, J.W., 1990. The water requirements and pollution potential of South African gold and uranium mines, WRC Report No. KV 9/90, Water Research Commission, Pretoria, 172 p.

(iv) Murray, K.A., 1987. Wastewater Treatment and Pollution Control, Water Research Commission, Pretoria, 367 p. (The publication provides useful information on the mining; cellulose fibre; iron and steel; tanning; textile; brewing; wine/brandy, and sugar industries in terms of water consumption and water quality).

(v) Stander, G.J., 1954. Waterbewaring en doeltreffende beplanning vir die maksimum-eksploitasie van Suid-Afrika se natuurlike hulpbronne, Tydskrif vir Wetenskap en Kuns, VOL 14(2), Nuwe Reeks, p. 162 - 177. (The paper is an historical overview of water consumption in South Africa, with reference to selected industrial and agricultural activities. A brief summary can be found in: Stander, G.J., 1955. Water en watergebruik in Suid-Afrika, Tydskrif vir Wetenskap en Kuns, VOL 15(2), Nuwe Reeks, p. 220 - 224).

(vi) Stander, G.J., 1970. The potential of water reclamation in South Africa, Water Year 1970, Convention on Water for the Future, [Department of Water Affairs], 16 - 20 November 1970, Pretoria, 6 p. (The paper contains older, although relevant, water reuse data).

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* See Anonymous, 1986. Management of the Water Resources of the Republic of South Africa, Department of Water Affairs, Pretoria, various pages.

Note:

(i) The term "SWI" refers to the Specific Water Intake of the industry concerned, namely, the volume of water required per unit of product. The term "SPL" refers to the Specific Pollution Load, namely, the mass of pollutant per unit of product for a given industrial activity. The term "WRCU" (Water Related Cattle Unit), provides a method for comparing abattoir water consumption data for the various types of livestock, by relating the numbers of each animal to a standard of one cattle unit. COD (Chemical Oxygen Demand) is a measure of the organic content of water, while UHT refers to the Ultra High Temperature milk treatment process.

(ii) Most industrial water is used for cooling and waste disposal. Generally, only 5 - 10% is "consumed" and the rest is discharged (normally to sewers), or is lost to the atmosphere (Morris, 1971)*.

(iii) Mining operations and power generation were excluded from the survey, which examined premises using more than 50 m^3 of water on a daily basis for industrial purposes. Much of the data for the survey were not derived from Natal/KwaZulu (excluding the sugar industry).

(iv) Steffen, Robertson and Kirsten Inc. (1991 - above) made the point that the overall industrial survey water intake data as determined for the Vaal Barrage catchment area (which produces some 50% of the Gross National Product of South Africa), was approximately 289 Mℓ day^{-1} or 106 x $10^6 m^3 y^{-1}$. Such a consumption figure is very low (7,3%) by comparison with an estimated total industrial water consumption for the whole of South Africa, of 1 448 x $10^6 m^3 y^{-1}$ as at 1990, provided by the then Department of Water Affairs (Anonymous, 1986 - above). Steffen, Robertson and Kirsten Inc. accordingly suggested that the "official" industrial water consumption figure for South Africa is a considerable overestimate. (See the chapter on the surface water resources of Natal/KwaZulu).

(v) Steffen, Robertson and Kirsten Inc. also observed that South African industry in general (in recent times), has greatly improved its water management procedures, and is probably operating at water intake volumes which would make further reductions due to drought, for instance, extremely difficult for most industries. (The malt brewing industry as an example, has reduced the SWI from a mean of some 9 m^3 per m^3 of beer produced to approximately 6 m^3 per m^3 of beer produced in the last 10 years).

(vi) In the study of industries in the Vaal Barrage catchment area Steffen, Robertson and Kirsten Inc. found that the malt brewing industry and the food miscellaneous category (mainly yeast and yeast-based products), were the most significant in terms of pollutant load. These industries plus the chemicals, plating (and metal finishing),

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* See Morris, S.S., 1971. The role of water in urban communities, South African Journal of Science, VOL 67(3), p. 73 - 85.

paper products, fruit and vegetables and red meat industries contributed 75% of the wastewater volume, 78% of the COD load and 75% of the total dissolved solids load discharged by industry, to sewage works in the Vaal Barrage catchment area. On an overall basis, industrial return flows of wastewater either via sewage works or directly to watercourses (within or outside the study area) amounted to 140 Mℓ day^{-1}, or 48% of the total daily industrial water intake in the Vaal Barrage catchment area. (The WRC report provides a useful list of the various industrial categories in terms of wastewater loads on sewage works in the Vaal Barrage catchment area).

(vii) Reference should also be made to the specific CSIR and Water Research Commission reports dealing with wastewater on an individual industrial category basis - see the section on Water quality problems in South Africa in the chapter on water quality.

(viii) The volume of water needed for crop and vegetable production varies and depends on several factors including the type of crop/vegetable; the climate; the soil; the use of irrigation, and the growth stage of the plants. Nel (1991)* estimated typical water consumption as follows: maize (500 ℓ kg^{-1} of harvested product); wheat (600 ℓ kg^{-1}); livestock feed - such as lucerne (500 ℓ kg^{-1}); cabbages (34 ℓ kg^{-1}); green beans (88 ℓ kg^{-1}), and tomatoes (48 ℓ kg^{-1} of harvested product).

12.3 Major infrastructure projects in the black townships of Natal/KwaZulu

12.3.1 Historical background

Many of the projects (in recent times), were undertaken in the Durban Functional Region and in the Pietermaritzburg Metropolitan Area (the primary urban concentration in Natal/KwaZulu, subject to rapid population influx and movement from one area to another). A most important programme was the RSA-KwaZulu Development Project, which followed on from work begun by the KwaZulu/Natal Planning Council. The function of the RSA-KwaZulu Development Project undertaken jointly by the South African and KwaZulu governments, was to upgrade the infrastructure and living conditions in several large

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* Nel, P., 1991. Personal communication, Department of Plant Production, University of Pretoria, Pretoria. Further brief data on crop and vegetable water consumption in terms of physical water use efficiency, can be found in: Backeberg, G.R., Bembridge, T.J., Bennie, A.T.P., Groenewald, J.A., Hammes, P.S., Pullen, R.A. and Thompson, H., 1996. Policy proposal for irrigated agriculture in South Africa: discussion paper, WRC Report No. KV 96/96, Water Research Commission, Pretoria, 119 p.

townships of Natal and KwaZulu*. The areas concerned were inter alia Umlazi, Inwabi, Umbumbulu, KwaMakhutha, the Greater Inanda area (including KwaMashu, Ntuzuma, Released Areas 33 and 91 - see Chapter 10 for a brief discussion of released areas - Mission Station and Mission Reserve), Clermont, KwaDabeka, Emolweni, KwaNdengezi, Dassenhoek and Salem - all in the Durban Functional Region; and Greater Edendale, Vulindlela and Mpophomeni in the Pietermaritzburg Metropolitan Area. A number of similar initiatives also operated mainly in the Durban Functional Region, including Project Natalia (launched by the former Department of Planning and Provincial Affairs), as well as activities undertaken by the (now defunct) Urban Foundation. On-going projects include those of the Independent Development Trust, P O Box 16114, Vlaeberg, 8018, and Operation Jumpstart (the latter funded by Natal Lotto, P O Box 40, Durban, 4000 - a lottery company owned by the Operation Jumpstart Association)**.

12.3.2 The Reconstruction and Development Programme

Following the 1994 elections, a major new policy applicable to the entire country, namely, the Reconstruction and Development Programme (the RDP) was announced by the Government. The aim of the RDP is to improve the quality of life of all South Africans, particularly those who lack access to basic services***. Many RDP projects therefore

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* See Davis, A.B. and Viljoen, P.S., 1988. The KwaZulu/Natal Planning Council work on the current status of water supply and sanitation in the Pietermaritzburg and Durban Metropolitan areas, Paper No. 2.1, Seminar on Water Supply and Sanitation - KwaZulu, South African National Committee of the International Water Supply Association, the Division of Water Technology of the CSIR, the KwaZulu Government and the Department of Development Aid, 28 - 30 June 1988, Durban, 14 p. See also, Viljoen, P.S., 1992. Update on the RSA/KwaZulu Development Project (RKDP), Shelter, August 1992, p. 1 - 8.

** See Bekker, S. and Singh, P., 1990. Will too many cooks spoil Durban's development broth?, Indicator South Africa, VOL 8(1), p. 59 - 63., and Harrison, P., 1991. Towards an effective institutional framework for planning in Natal/KwaZulu, Monitor, No. 12, First Quarter 1991, p. 12 - 14. See also, Robinson, P., 1991. Operation Jumpstart: a good reason for optimism, The Condenser 1991, p. 37 - 40. (Operation Jumpstart is a private sector initiative to create employment, to provide infrastructure and to upgrade educational facilities). A useful overview of the various programmes can be found in Developer, No. 40, July/September 1991 (most of the issue).

*** The RDP was designed as the framework for a wide range of policies, in order to promote economic growth and to reduce extreme inequalities in income. Accordingly, improved trade and industry policies, monetary and fiscal discipline, the reform of labour market institutions and the modernization of human resources programmes, all form an integral part of the RDP. Details of the RDP can be obtained from the RDP Coordinator, KwaZulu-Natal Department of Economic Affairs and Tourism, 216 Boshoff Street, Pietermaritzburg, 3201. Information on the Masakhane programme can be obtained from the National Campaign Manager: Masakhane, Private Bag X804, Sunnyside, 0132/the Chief Directorate: Local Government Administration, KwaZulu-Natal Department of Local Government and Housing, Private Bag X9078, Pietermaritzburg, 3200.

concentrate on the provision of infrastructure such as water, sanitation, waste disposal, health facilities, roads, energy and housing, as well as land reform. Emphasis in the RDP is placed on co-operation between residents and the Government as well as private sector agencies. RDP projects accordingly, do not involve a "hand out", and residents are required to identify and to motivate for priority projects in their own areas. The RDP programme operates in conjunction with the Masakhane ("Let us build each other") campaign, which is partly aimed at encouraging payment for services in the black townships. Restricted local government capacity, poverty, faulty perceptions, crime and political interference however, are major impediments*. The RDP programme is under the control of the Deputy President of South Africa.

A detailed analysis of the RDP (and the associated financial, health and environmental implications)** will not be possible until such time as a substantial number of projects has been completed, and the relevant data are available. The Quality of Life and RDP Monitoring Unit, Centre for Social and Development Studies, University of Natal, Private Bag X10, Dalbridge, 4014, has an on-going research programme aimed at assessing general perceptions of the impact of RDP projects on people's lives. The programme (funded by the Human Sciences Research Council), operates in various parts of South

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* The seemingly-endless cycle of non-payment must be stopped. Inadequate services result in non-payment as a means of protest: reduced municipal revenues in turn, imply inadequate services. Payment will not bring improved services in the short term, although each payment is a step in the right direction. The present situation is not helped by anti-social and criminal elements who damage infrastructure and/or steal equipment, and who attack municipal staff. Essential maintenance work is an obvious casualty.

** The environmental impacts of RDP projects should be carefully considered at all stages of the project cycle. The Council for the Environment, Private Bag X447, Pretoria, 0001, recommended that a Streamlined Environmental Impact Assessment should be undertaken for RDP and similar "fast-track" programmes. See, Council for the Environment, 1994. SEIA: streamlined environmental impact assessment, [Department of Environmental Affairs and Tourism], Pretoria, 10 p. + app. See also, Baskind, P., Holland, J., McKenzie, C. and Weilbach, D., 1994. Environmental analysis: requirements and monitoring procedures, Internal Operating Guideline Paper No. 1, Environmental Policy Programme, Development Bank of Southern Africa, Halfway House, 15 p.

Africa. Five core documents should be carefully examined by readers in search of background information on the RDP*.

12.4 Water and sanitation planning in black urban areas of Natal/KwaZulu

12.4.1 RSA-KwaZulu Development Project guidelines

The technical co-ordinators of the RSA-KwaZulu Development Project, namely, Van Wyk and Louw Inc. (now Africon Engineering International Ltd), P O Box 1319, Westville, 3630, compiled a series of guidelines/standards for the upgrading of existing areas; and for the planning of new residential suburbs and towns in black settled areas. The guidelines have important implications for the design of water and sanitation infrastructure, including water demand. The guidelines were developed from the so-called "Blue book" and the "Green book", produced by the (former) Department of Community Development and the (former) Department of Development Aid respectively**. Planning guidelines provided by the RSA-KwaZulu Development Project concern inter alia amenities (Table L8); secondly, infrastructure options (Table L9) and thirdly, water consumption guidelines (Table L10). Department of Community Development water demand (design) data are presented in Table L11.

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* See African National Congress, 1994. The Reconstruction and Development Programme: a Policy Framework, Umanyano Publications, Johannesburg, 147 p., as well as Anonymous, 1994. RDP White Paper: discussion document, [Government Printer], [Pretoria], 60 p., and Anonymous, 1994. White Paper on Reconstruction and Development, WPJ/1994, Government Gazette No. 16085 of the 23rd November 1994, Government Printer, Pretoria, 81 p. (Government Notice GN 1954/94). See in addition, the RDP Monitor, published by Stock Information Services Ltd, P O Box 938, Pinegowrie, 2123. The monthly publication (VOL 1(1), June/July/August 1994 - current), provides brief details on both national and international media coverage of the RDP, with editorial comment. Examine also, RDP News, a monthly/bi-monthly compendium of RDP projects and news (No. 1, January 1995 - current), published by the South African Communication Service, Private Bag X745, Pretoria, 0001. Further information on the RDP can be obtained through the perusal of newspaper columns. In this regard, it should be noted that the University of the Orange Free State provides a cuttings service (known as INCH/INEG), based on 85 South African newspapers and journals (see Table B7 in Chapter 2). Contact the Institute for Contemporary History, P O Box 2320, Bloemfontein, 9300. The Regional Research and Reporting Corporation, P O Box 13060, Clubview, 0014, publishes Focus, a monthly collation of important press cuttings on political, economic and social news, drawn from 10 South African newspapers.

** The latter Department assumed some of the housing functions of the Department of Community Development, following the Department's closure in 1983. The Department of Development Aid was first known as the Department of Native Affairs, thereafter the Department of Bantu Administration and Development, then the Department of Plural Relations and Development, and was subsequently known as the Department of Co-operation and Development. The Department was dissolved in December 1991.

Table L8: **RSA-KwaZulu Development Project planning guidelines/standards for amenities in terms of the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990.**

Amenity	Details
Civic/cultural amenities	
Town centre	One per town
Community centre/hall	One per community
Local administration office	One per community
Central administration office	One per town
Library	One per 3 - 5 communities
Municipal depot	One per town
Fire station	One per town
Cemetery	As per formula - see Anonymous (1985 - below)
Neighbourhood clinic	One per community
Major clinic (24 hours)	One per 5 000 residential sites
Community hospital	One per town
Regional hospital	One per region
Police station	One per town
Court building	One per town
Prison	One per region
Post office	One per 3 - 5 communities
Telephone exchange	One per 20 000 residential sites
Pre-primary school	One per 500 residential sites
Primary school (assuming 1 000 pupils with 28 classrooms, and one multi-purpose centre)	One per 650 residential sites (high socio-economic status) One per 550 residential sites (middle socio-economic status) One per 500 residential sites (low socio-economic status)
Secondary school (assuming 1 000 pupils with 42 classrooms)	One per 1 300 residential sites (high socio-economic status) One per 1 375 residential sites (middle socio-economic status) One per 1 500 residential sites (low socio-economic status)

Table L8: **RSA-KwaZulu Development Project planning guidelines/standards for amenities in terms of the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990 (continued).**

Amenity	Details
Technical high school	One per town
Technical college	One per town
Technikon	One per town
Creche	One per 600 residential sites
Places of worship	One per neighbourhood
Old age home	One per 3 - 5 communities
Reformatory	One per town
Orphanage	One per town
Institute for the mentally retarded	As per town plan
Children's playground	One per 150 residential sites
Sports field	One per community
Swimming pool	One per 3 - 5 communities
Sports stadium	One per town
Passive open space	As per town plan
Housing amenities High socio-economic status	Residential sites >400 m^2
Middle socio-economic status	Residential sites 250 - 400 m^2
Low socio-economic status	Residential sites <250 m^2
Commercial/service amenities Corner shops	One per neighbourhood
Other amenities	As per town plan
Industrial amenities	As per town plan

Source: After Anonymous, 1990. RSA-KwaZulu Development Project technical guidelines and standards, Van Wyk and Louw Inc., Pinetown, various pages.

Note: (i) The guidelines/standards are not prescriptive and are intended as a guide only. The local authority ultimately determines the locality and number of amenities, based inter alia on projected or present population, existing facilities (if any), and topography.

(ii) In terms of the guidelines one neighbourhood = 450 residential sites. One community = 2 700 residential sites in an area of approximately 250 ha - normally accommodating some 20 000 people.

(iii) Further reference should be made to the Blue book, namely, Anonymous, 1983. Guidelines for the provision of engineering services for residential townships, Department of Community Development, Pretoria, various pages (Part F - water supply), and to the Green book, namely, Anonymous, 1988. Towards guidelines for services and amenities in developing communities, Department of Development Aid, Pretoria, various pages. See also: Anonymous, 1985. Ruimtelike standaarde vir uitlegbeplanning in swart dorpe, Department of Co-operation and Development, Pretoria, 47 p.

(iv) It is important to note that the Blue and Green books have been replaced by an updated version known as the "Red book". See Anonymous, 1994. Guidelines for the provision of engineering services and amenities in residential township development, Department of National Housing and the National Housing Board, Pretoria, various pages. The publication (compiled by the Division of Building Technology, CSIR, Pretoria), contains useful cost data for specific services, as at 1994. Information on costs presented in this chapter must be viewed as historical data, and reference should be made where necessary to the Red book. Regular revision of the latter document is planned for the future.

(v) Site areas are not given in the table, although they can be found in Anonymous (1990 - above).

(vi) Interested readers should examine the following report: Anonymous, 1990. Inanda - portions of the freehold area: development framework report, prepared for the Directorate: Physical Services, Chief Directorate: Planning Services, Department of Development Aid, Project No. Z87003, Inanda Development Project, VOL 1, J.C. Theron Burke and Isaac Inc., Pinetown, 137 p. + app. (The publication inter alia provides a comparison of several proposed planning standards for Inanda including the RSA-KwaZulu Development Project technical guidelines/standards, plus development options for residential areas. Besides Theron Burke and Isaac Inc. (the project co-ordinators), De Leuw Cather Marsh, Plan Associates, PlanKonsult, Rob Kirby Associates and Terraplan Associates - all of Durban/Westville - were involved in the planning proposals. The document is an informative example of the use of planning guidelines in practical reality, where Inanda constitutes an ideal case study).

Table L9: **RSA-KwaZulu Development Project infrastructure options for the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990.**

Development option	Water supplies	Sanitation	Bus routes	Streets	Electricity	Refuse
1	Vending through water kiosks or metered standpipe vending points. Spacing as per site requirements (approximately one source every 250 m)	VIP or VIDP latrine as necessary	Gravel roadway, open drains, levelled walkways (only if practical)	Tracks, surveyed road reserves, no formal drains, crossflow, waterbars. On land steeper than a gradient of 1 : 2,5 pedestrian access only - road within 250 m of house	None (can be provided later if required - 1,5 kVA connection plus 12 street lights km^{-1})	Central skip system
2	Vending through water kiosks or metered standpipe vending points. Spacing as per site requirements (approximately one source per 10 residential sites)	VIP or VIDP latrine as necessary	Gravel roadway, open drains, levelled walkways (only if practical)	Gravel roadway, levelled walkways, combination of open drains in areas of excessive stormwater accumulation (lined or unlined), and no drains (crossfall) in others	None (can be provided later if required - 1,5 kVA connection plus 12 street lights km^{-1})	Central skip system

Table L9: RSA-KwaZulu Development Project infrastructure options for the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990 (continued).

Development option	Water supplies	Sanitation	Bus routes	Streets	Electricity	Refuse
3	Vending through water kiosks or metered standpipe vending points. Spacing as per site requirements (approximately one source per 10 residential sites)	VIP or VIDP latrine as necessary	Gravel roadway, open drains, levelled walkways (only if practical)	Gravel roadway, levelled walkways, combination of open drains in areas of excessive stormwater accumulation (lined or unlined), and no drains (crossflow) in others	None (can be provided later if required - 1,5 kVA connection plus 12 street lights km^{-1})	Central skip system or door to door collection
4	Metered standpipe on site. Owner to pay for connection from property boundary to standpipe (including meter assembly and standpipe), and to provide a soakpit as required	VIP or VIDP latrine or suitable alternative on site, wet disposal sanitation system as necessary	Paved roadway, levelled walkways (paved if required), kerb/channel or lined open drains	Gravel roadway, levelled walkways, combination of grassed and lined open drains, no crossflow	1,5 kVA connection plus 12 street lights km^{-1}	Central skip system or door to door collection

Table L9: RSA-KwaZulu Development Project infrastructure options for the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990 (continued).

Development option	Water supplies	Sanitation	Bus routes	Streets	Electricity	Refuse
5	Metered connection. Owner to pay for connection from yard boundary to house, including meter assembly	Waterborne, owner to arrange and to pay for house connection to sewer	Paved roadway, levelled walkways (paved if required), kerb/channel or lined open drains	Paved roadway, levelled walkways, lined open drains	1,5 kVA connection plus 12 street lights km^{-1}	Door to door collection
6	Metered connection. Owner to pay for connection from yard boundary to house, including meter assembly	Waterborne, owner to arrange and to pay for house connection to sewer	Paved roadway, levelled walkways (paved if required), kerb/channel or lined open drains	Paved roadway, levelled walkways, kerb and channel drains	Reticulated for house connection, 1,5/2,5 kVA connection plus 24 street lights km^{-1}	Door to door collection

<u>Source</u>: (i) After Anonymous, 1990. RSA-KwaZulu Development Project technical guidelines and standards, Van Wyk and Louw Inc., Pinetown, various pages.

(ii) After Viljoen, P.S., 1986. Development initiatives of the KwaZulu/Natal Planning Council in the informal black settlements around Durban, <u>Civil Engineer in South Africa</u>, VOL 28(6), p. 211 - 217, 229.

<u>See also</u>: (i) Palmer, I. and Eberhard, R., 1994. Evaluation of water supply to developing urban communities in South Africa, Phase 1 - overview, WRC Report No. KV 49/94, Water Research Commission, Pretoria, various pages.

(ii) Rivett-Carnac, J.L., 1989. An evaluation of public water vending systems in the Durban Metropolitan Area, Report No. TR 405, Appropriate Technology Information, Pietermaritzburg, 26 p.

Note:

(i) The cost of supplying the infrastructure ratio (excluding certain services and the cost of the land) in 1989, using Option 1 as a baseline and assuming the highest level of services for each option, was approximately as follows 1 : 1,42 : 1,67 : 2,19 : 3,74 : 4,14. Actual costs will depend on site and other conditions.

(ii) VIP refers to Ventilated Improved Pit toilets (latrines), while VIDP refers to Ventilated Improved Double Pit latrines.

(iii) The various services are not fixed for a given option and different combinations of services are possible. The development options accordingly, are a guide only.

(iv) The assumed density is 20 - 25 residential sites ha^{-1}.

(v) The 1989 selling price of infrastructure per residential site less than 750 m^2 in proclaimed townships on (former) South African Development Trust land and in KwaZulu was as follows:

Pillar taps, pit latrines and roads (graded only)	R 600
Pillar taps, pit latrines and gravel roads	R1 200
Water, pit latrines and gravel roads	R1 200
Pillar taps, sewerage and gravel roads	R1 300
Water, sewerage and gravel roads	R1 400
Water, sewerage and tarred roads	R2 400

(vi) Option 4 (metered standpipe/pillar tap on individual sites) is not generally recommended, but should be allowed as an upgrading option, if accompanied by a properly designed facility for the disposal of wastewater. The upgrading of an area from Options 1 - 3 to Option 4 is considered feasible. For design purposes, assume that 50% of such areas will ultimately consist of Options 1 - 3, and that the remainder will upgrade to Option 4. Design however, does not allow for upgrading from Options 1 - 4 to Options 5 - 6.

(vii) Further reference should be made to the Blue book, namely, Anonymous, 1983. Guidelines for the provision of engineering services for residential townships, Department of Community Development, Pretoria, various pages (Part F - water supply), and to the Green book, namely, Anonymous, 1988. Towards guidelines for services and amenities in developing communities, Department of Development Aid, Pretoria, various pages. See also Footnote (iv) of Table L8.

Table L10: RSA-KwaZulu Development Project water demand guidelines for the upgrading of existing areas, and for the establishment of new black (urban) residential sites and towns in Natal/KwaZulu, 1990.

Development option/land use category	Annual mean daily water demand (ℓ)
Domestic (1 - 3)	30 ℓ $capita^{-1}$ day^{-1} (assuming an average occupancy of eight persons per dwelling)
Domestic (4)	50 ℓ $capita^{-1}$ day^{-1} (assuming an average occupancy of eight persons per dwelling)
Domestic (5)	950 ℓ $site^{-1}$ day^{-1} (metered connection)
Domestic (6)	950 ℓ $site^{-1}$ day^{-1} (metered connection)
Schools and creches	25 kℓ $site^{-1}$ day^{-1}
Hospitals	50 ℓ $outpatient^{-1}$ day^{-1}
Industrial areas	25 kℓ ha^{-1} day^{-1}

Source: After Anonymous, 1990. RSA-KwaZulu Development Project technical guidelines and standards, Van Wyk and Louw Inc., Pinetown, various pages.

Note:

(i) An allowance of 15% of the estimated annual mean daily demand must be added to the calculated peak demand, to cover losses and other minor water usage in commercial centres and local authority offices.

(ii) The instantaneous peak flow rates for Options 1 - 3 are based inter alia on the assumption (with all standpipes in use), that a single standpipe or pillar tap delivers 15 ℓ min^{-1}, with double standpipes or pillar taps delivering 25 ℓ min^{-1}.

(iii) For the purposes of calculating instantaneous peak flow rates, the annual mean daily demand for one "equivalent erven" or residential site with regard to Options 5 - 6 is assumed to be 950 ℓ. The formula is: annual mean daily demand x peak factor + 15% (as above).

(iv) In Options 1 - 4, the reticulation network is not designed to carry fire flows. Options 5 - 6 are assumed to be low risk Group 3 areas - residential zone I (according to the Blue book). See Table L11.

(v) The reservoir storage capacity must be no less than 48 hours of the annual mean daily demand, irrespective of the method of supply to the reservoir.

(vi) Further reference should be made to the Blue book, namely, Anonymous, 1983. Guidelines for the provision of engineering services for residential townships, Department of Community Development, Pretoria, various pages (Part F - water supply), and to the Green book, namely, Anonymous, 1988. Towards guidelines for services and amenities in developing communities, Department of Development Aid, Pretoria, various pages. See also Footnote (iv) of Table L8.

Table L11: Department of Community Development water demand guidelines.

Category and type of development	Unit	Annual mean daily water demand (ℓ)
1. Dwelling houses (residential zone I)	Erf area ($\leq$600 - 2 000 m^2) for dwelling house	Upper limit 1 200 - 3 450 Lower limit 600 - 2 100
2. Low-rise multiple dwelling-unit buildings (residential zones II and III)	Dwelling	Upper limit 1 000 Lower limit 600
3. High-rise multiple dwelling-unit buildings (residential zone IV)	Dwelling	Upper limit 700 Lower limit 450
4. Offices and shops	100 m^2 of gross floor area	400
5. Government and municipal buildings	100 m^2 of gross floor area	400
6. Clinics	100 m^2 of gross floor area	500
7. Places of worship	Erf	2 000
8. Hostels	Occupant	150 ℓ $occupant^{-1}$
9. Developed parks	Hectare of erf area	$\leq$2 ha - 15 kℓ $>$2 ha $\leq$10 ha - 12,5 kℓ $>$10 ha - 10 kℓ
10. Day schools	Hectare of erf area	As per developed parks
11. Boarding schools	Hectare of erf area plus boarders	As per developed parks plus 150 ℓ $boarder^{-1}$
12. Sports grounds	Hectare of erf area	As per developed parks
13. Creches	Hectare of erf area plus inhabitants	As per developed parks plus 75 ℓ $capita^{-1}$
14. Public open spaces	-	Nil

<u>Source</u>: After Anonymous, 1983. Guidelines for the provision of engineering services for residential townships, Department of Community Development, Pretoria, various pages (Part F - water supply).

Note:

(i) The water demand data adopted for design purposes should be based on a projected value, say 20 years hence. The data provided in the table allow for rising standards of living and are the actual figures anticipated for the year 2000, based on a 2% per annum compounded growth. The tabulated information applies to townships with flush sanitation and one or more taps in the yard, or inside the building. Upper limits refer to high income townships and the lower limits to lower income townships.

(ii) Residential zone I implies one dwelling house and an outbuilding per erf (normally the largest residential category in a town), while residential zones II and III include multiple dwelling-unit buildings up to three storeys high (excluding a basement). Residential zone IV concerns high rise multiple dwelling-unit buildings of four storeys and more. The design criteria are based on residential sites (erven) of less than 2 000 m^2. For erven larger than 2 000 m^2, demand should be determined as per local conditions.

(iii) Demand data for categories 1 - 3, include garden watering of all common areas outside the limits of the buildings.

(iv) The gross floor area is obtained using the applicable floor space ratio derived from the relevant town planning scheme.

(v) Water demand for developed parks (category 9), must be considered as being drawn over six hours on any given day, in order to obtain the peak demand. Where the designer anticipates the development of parks and sports grounds to be of a high standard (25 mm of water applied per week), the annual mean daily water demand should be taken as: $\leq$2 ha - 50 kℓ; >2 ha $\leq$10 ha - 40 kℓ, and >10 ha - 30 kℓ.

(vi) In order to calculate instantaneous peak flow rates, the various types of development and consequent design demand should be converted to standardized "equivalent erven", where the annual mean daily demand is assumed to be 1 000 ℓ per equivalent erven.

(vii) Reservoirs (with a gravity or pumped supply from one water source), should have a minimum storage capacity of 48 hours of the annual mean daily demand. Where the reservoir has a gravity or pumped supply from two water sources, a minimum storage capacity of 36 hours is recommended.

(viii) The water supply system for emergency or temporary low cost housing should consist of standpipes with 15 mm nominal size taps situated in street reserves, with approximately one tap for every 10 houses, or located within 75 m of a given house. The total daily demand for the township should be based on a demand rate of 5 kℓ ha^{-1} day^{-1} for the gross developable area of the township.

12.4.2 Durban Metro Water guidelines

An innovative water supply strategy devised by the recently established (in 1995) Durban Metro Water, P O Box 1038, Durban, 4000 - a municipal water supply agency for the Durban Metropolitan Area - involves three levels of service for black peri-urban and urban settlements. The first level consists of a fully reticulated system, operating at standard water pressure (more than 600 ℓ site^{-1} day^{-1}). The second level of service concerns the use of a 200 ℓ roof tank, supplied from water mains in the street (400 - 600 ℓ site^{-1} day^{-1}). Such an option is considerably cheaper than full pressure, and provides most of the benefits of standard reticulation. An outside 200 ℓ ground level tank constitutes the third level of service (up to 200 ℓ site^{-1} day^{-1}), which is used where householders cannot afford roof tanks or full reticulation. The outside tank is usually connected to the house*. The supply to 20 - 25 households is controlled from one manifold, with small bore pipes linking the water mains and each household (ground level) tank. Water bailiffs (members of the resident community) are responsible for operating the latter system, where monthly pre-payment is required. The bailiffs are self-employed entrepreneurs who derive some income from the water scheme. The cheapest system may also include approximately one public standpipe per 200 - 300 households. The standpipe (which is an interim measure), is situated in the yard of the relevant water bailiff. The purchase of water from the bailiff is on a cash only basis. Householders are billed in the normal manner where the standard municipal system and the roof tank method are in operation. The outside tank can be upgraded to a roof tank, if required (Macleod, 1996)**.

Sanitation provision will be directly linked to the water service level. A draft sanitation policy is presently under consideration. A Ventilated Improved Pit (VIP) toilet (provided access for emptying is possible), or other appropriate on site disposal system, is specified at households with a ground level tank. State housing funds will be used to purchase and build the system at low cost housing schemes. Individual householders may also wish to buy the components and install the system themselves (in order to save money), or to employ a private contractor. On site sanitation (a VIP toilet with soakaway, a septic tank

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* Brief guidelines for the use of on site household storage tanks can be found in the Blue book - see Table L11.

** Macleod, N., 1996. Personal communication, Durban Metro Water, Durban. (Durban Metro Water was formed from 11 local authorities and other Government agencies hitherto responsible for the supply and distribution of water in their own areas of jurisdiction).

or a French drain), will only be permitted at households with a roof tank, if soil conditions and topography are acceptable. The undeveloped plot size must also be larger than 200 m^2. Wastewater volumes must not be excessive. These restrictions will apply in order to prevent groundwater pollution. Methods of installation and payment will be the same as per ground level tank households. In circumstances where on site sanitation at roof tank households is not advisable, the excess water must be removed from the plot (probably by conventional waterborne sewerage, although this still has to be decided). Removal of wastewater from the plot however, rather than on site sanitation, is the preferred option. Waterborne sewerage will usually be installed at households with standard water pressure. The service provider will be responsible for installing trunk mains to the subdivision boundary. Reticulation to the yard boundary will be undertaken by the developer (State or private sector). Charges for waterborne sanitation will be added to the monthly household water account. Septic tanks (again subject to site conditions), are also an option at households with standard water pressure (Davis, 1996)*.

12.4.3 Department of Water Affairs and Forestry guidelines

Guidelines for the provision of water and sanitation services with special reference to the less developed areas of South Africa were outlined in a White Paper, which was released in 1994**. The Department of Water Affairs and Forestry, in terms of the RDP, now places considerable emphasis on domestic water and sanitation services; and the facilitation of these services within a defined policy framework (briefly described in the chapter on health). The guidelines are based on a number of principles - the most important of which - is the recognition that basic services are a human right. The primary objective of the Department is to ensure "some (services) for all", rather than "all for some". The equitable regional allocation of scarce financial, planning and technical resources (depending on population and level of development), is accordingly necessary to achieve this goal. Other principles of the new policy include the requirement that decision making and the control of services should be devolved as far as possible to local structures, with residents motivating for and accepting responsibility for their own

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* Davis, A., 1996. Personal communication, Durban Metro Wastewater Management, Durban. (It should be noted that Durban Metro Wastewater Management, Durban Metro Water and Durban Solid Waste, are departments of Durban Water and Waste).

** See Anonymous, 1994. White Paper on Water Supply and Sanitation Policy, Report No. WP-I, Department of Water Affairs and Forestry, Cape Town, 38 p.

schemes*. A central theme of the policy is that the user pays, which also applies within certain constraints, to poor households receiving improved services.

The White Paper recognized the fact that good quality water in South Africa has a presently underestimated economic value, and must be carefully allocated and consumed in order to ensure long term economic growth and sustainability. Environmental concerns are likewise of importance, where the provision of large and small scale water and sanitation services should not be at the expense of the environment. The latter requirement reinforces the need for integrated development, and therefore the maximum co-operation of all development agencies including other Government departments, water and irrigation boards, local authorities, and non-government organizations.

The primary operational objective of the Department, as stated in the White Paper, is to ensure that all households have access to basic water and sanitation services within a period of seven years or less. The minimum standard set by the Department for water schemes, involves a supply of at least 25 ℓ capita^{-1} day^{-1}. This threshold is regarded as the minimum necessary for direct consumption, food preparation and personal hygiene. The supply source should be situated within 200 m of a dwelling, or less in steep terrain. A minimum delivery of at least 10 ℓ min^{-1} has been specified for the outlet point. The water must be available on a regular basis**. Raw water for the scheme should accordingly be secured for 98% of the time with no failures, on average, during a 1 : 50 year drought. It follows that the operation and maintenance of the scheme must also be efficient, where supply interruptions due to technical problems should not exceed one week a year. The quality of the water should conform to currently accepted microbiological and chemical criteria (see the chapter on water quality). It is important to allow for the later upgrading of the service, for example household connections, during the

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* Various practical problems however, are evident in the South African context. For a discussion of some of these difficulties see, Heymans, C., 1994. Setting agendas where the issues are: the developmental limits and possibilities of local-level urban planning and management processes, Development Southern Africa, VOL 11(1), p. 33 - 48.

** A useful series of papers dealing with urban water demand projections is the following: Pretorius, C.J., Viljoen, M.F., Van der Merwe, R.B. and Van Niekerk, I.E., 1995. Projektering van waterbehoeftes in stedelike gebiede (Deel 1): metodologiese oorsig, Water SA, VOL 21(1), p. 15 - 19., as well as Viljoen, M.F. and Pretorius, C.J., 1995. Projektering van waterbehoeftes in stedelike gebiede (Deel 2): 'n Ex post analise van die akkuraatheid van verskillende projeksiemetodes, Water SA, VOL 21(1), p. 21 - 26., plus Van Niekerk, I.E., Viljoen, M.F., Pretorius, C.J. and Van der Merwe, R.B., 1995. Projektering van watervraag in stedelike gebiede (Deel 3): die meervoudige regressiemodel as makro-projeksiemodel, Water SA, VOL 21(1), p. 27 - 36.

design phase of projects. Any additional infrastructure necessary to upgrade the service however, will not be regarded as part of the basic needs system - with cost implications for the residents.

The White Paper was less specific on sanitation guidelines, pending policy decisions inter alia on housing schemes*. The point was stressed that sanitation must be viewed in the broader context of health and hygiene education. The immediate priority is to provide sanitation services to all households in a manner which meets health requirements, as well as environmental parameters in terms of surface and groundwater quality. It was acknowledged that conventional waterborne sanitation in most cases, is not viable and achievable in the short term (due to cost). Adequate basic sanitation was defined as one properly constructed and maintained VIP toilet per household. Responsibility for the implementation and management of sanitation services falls within the jurisdiction of local authorities. The Department, or other agencies such as the water boards, will only act if there is no local authority - but only to establish a local delivery capacity. Residents seeking Government subsidies must provide evidence of widespread individual household support for the proposed scheme, including a financial contribution. A labour based approach to sanitation provision, using local labour and materials, was recommended. Second tier agencies including water boards will be required to train selected residents for the operation and maintenance of sanitation (and water) schemes. All sanitation projects must be in accordance with recognized housing standards.

The White Paper also provides information on costs, subsidies and tariffs for basic services (see the beginning of this chapter). The vexing question of State subsidies is receiving considerable attention and a definitive policy will only be finalized at some future date. Subsidies accordingly, are not discussed in any detail in this publication, but should be included in a second edition. In essence, the policy of the Department is that water and sanitation schemes should be self-financing at a local and regional level**. The only exception concerns poor communities who are unable to afford basic services. In such cases, the Department may subsidize the capital costs of construction of basic (minimum) services - excluding operating, maintenance and replacement costs.

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* A draft White Paper on sanitation policy per se will be released in the near future.

** For a discussion of some implications at local government level, see: Thompson, B., Palmer, I. and Eberhard, R., 1996. Financial modelling of municipal services in South African towns, Development Southern Africa, VOL 13(5), p. 745 - 758.

12.4.4 Other guidelines

Several water and sanitation guidelines were used in the past by local authorities and Government departments, according to circumstances. Details of current practices can be obtained inter alia from the provincial housing boards (see Section 12.9). A brief set of guidelines for rural and peri-urban areas is presently being finalized. Further information can be obtained from Umgeni Water, P O Box 9, Pietermaritzburg, 3200.

12.5 Alternative technology pumping equipment in Natal/KwaZulu

Water wheels and turbines were popular items of technology in Natal in earlier times. By 1880, some 42 water powered mills (mainly for agricultural purposes), were found in Natal (Russell, 1987)*. Until fairly recently, several farms in the Natal Midlands used water wheels or turbines. The use of alternative pumping technologies has declined markedly with the extension of ESKOM power to many farming areas in the last 10 years. The September 1987 floods also washed away or badly damaged numerous pumps. The implications are that local manufacturers have gone out of business and that manufacturing expertise is being lost. The following table (Table L12) lists sites where water wheels, turgo-wheels, pelton wheels and turbines may be found in operation. At a few sites, the water system while not functional, is virtually complete.

It is possible that selected items of technology could be used in certain rural areas of Natal/KwaZulu, to generate electricity and/or to pump water for irrigation and domestic requirements (for example, at schools, clinics and police stations). The use of water power however, is highly site specific, and requires a suitable terrain and sufficient river runoff. Secondly, other technologies such as windmills and wind-driven electricity generators, as well as solar energy (photovoltaic panels) - where not already in use - would need to be carefully considered in any (formal) alternative technology programme. These issues are complex and cannot be discussed here. Readers should examine the

* See Russell, G., 1987. 130 years of water power in Natal, [published by the author], Durban, 77 p.

Table L12: Some extant water wheels, turgo-wheels, pelton wheels and turbines in Natal/KwaZulu, 1993.

Name	Address	System
Northern Natal/KwaZulu		
B. Albers	P O Box 107, Melmoth, 3835	Water wheel
R. Klingenberg	P O Box 24, Luneburg, 3183	Turbine
W. Moolman	P O Box 331, Newcastle, 2940	Pelton wheel
A. Niebuhr	P O Box 132, Paulpietersburg, 3180	Turbine
H. Niebuhr	P O Box 22, Luneburg, 3183	Turbine
P. Rohrs/W. Rohrs	P O Box 107, Paulpietersburg, 3180	Turbines
Natal Midlands and environs		
C. De Nysschen	P O Muden, 3251	Water wheel
Dunlop Africa - Industrial Products Ltd	P O Box 29, Howick, 3290	Turgo-wheel
R. English	P O Box 242, Richmond, 3780	Pelton wheel
M. Harburn	P O Box 39, Rosetta, 3301	Pelton wheel
Harlestone Farm	P O Box 336, Mooi River, 3300	Turbine
P. Harms	P O Box 349, Mooi River, 3300	Turgo-wheel
G. Holland	P O Box 49, Bulwer, 3244	Modern water wheel
G. Laurens	Private Bag X3, Nottingham Road, 3280	Pelton wheel
A. Mackenzie	P O Lions River, 3260	Turbine
M. Macphail	P O Box 11001, Dorpspruit, 3206	Turbine and pelton wheel
S. McLean	P O Box 112, Himeville, 3256	Pelton wheel
H. Mingay	P O Box 45, Donnybrook, 3237	Turbine
G. Pascoe	P O Boston, 3211	Turbine
Reichenau Catholic Mission	P O Swamp, 4565	Damaged water wheel
K. Robinson	P O Boston, 3211	Turbine
P. Shaw	P O Box 570, Howick, 3290	Turbine
S. Solomon	P O Box 1136, Pietermaritzburg, 3200	Modern turbine and francis wheel
St Isadore Farm	P O Box 206, Ixopo, 3276	Pelton wheel

Table L12: Some extant water wheels, turgo-wheels, pelton wheels and turbines in Natal/KwaZulu, 1993 (continued).

Name	Address	System
N. Thurston	P O Box 14, Underberg, 3257	Pelton wheel
Weenen Town Board Museum	P O Box 13, Weenen, 3325	Water wheel
Natal South Coast, East Griqualand and Transkei		
D. Button	P O Box 15, Umzimkulu, 3297	Turbine
Mariazell Catholic Mission	P O Box 68, Matatiele, 4730	Pelton wheel
A. Matthee	Gun Drift, P O Mtamvuna, 4683	Turbine
Southern Natal Joint Services Board	P O Box 33, Port Shepstone, 4240	Turbine

Source: Fieldwork.

See also:

(i) Russell, G., 1987. 130 years of water power in Natal, [published by the author], Durban, 77 p. (Available from the author at 138 Belvedere Road, Redhill, 4051, or at the Natal Society Library, Pietermaritzburg).

(ii) Walton, J., 1974. Water-mills, Windmills and Horse-mills of South Africa, C. Struik, Cape Town, 204 p.

Note:

(i) Details of the design and construction of water wheels, rampumps, turbines, pelton wheels and turgo-wheels can be obtained from the following:

- M. Cotterrell, Ailsa Enterprises, P O Thomas River, 5311.
- Department of Agricultural Engineering, University of Natal, Private Bag X01, Scottsville, 3209. (Engineering faculties at other South African universities may also be able to provide technical information).
- E. Harries, Albert Falls Power Company Ltd, P O Cramond, 3220. (Note: The firm has closed down, although technical expertise is still available).
- W. Harrington, P O Boston, 3211.
- G. Holland, P O Box 49, Bulwer, 3244.
- Nelson Adams, P O Box 240, Brackenfell, 7561.

- Turbomachinery Research Group, Department of Mechanical Engineering, University of Natal, Private Bag X10, Dalbridge, 4014.

- P. Wessels, Agrirain cc, P O Box 826, Pietermaritzburg, 3200.

(ii) Very few alternative and conventional technology demonstration sites are found in South Africa. An important source of information is the site maintained inter alia by the Institute for Agricultural Engineering (formerly part of the Chief Directorate: Agricultural Engineering and Water Supply of the Department of Agriculture), now part of the Agricultural Research Council, Private Bag X519, Silverton, 0127*. Other organizations involved with the site are the Department of Mineral and Energy Affairs, ESKOM and the Solar Energy Society of Southern Africa. A small static display (mainly consisting of borehole handpumps) can be viewed at the Amatikulu Primary Health Centre, KwaZulu Department of Health, Private Bag X2113, Nyoni, 3802. A wind energy demonstration and testing centre has been established in Port Elizabeth by ESKOM and the Port Elizabeth Technikon, Private Bag X6011, Port Elizabeth, 6000. A research programme involving ESKOM and the Department of Geographical and Environmental Sciences, University of Natal, Durban, was initiated a few years ago at Mabibi on the shores of Lake Sibayi - see the bibliographic database. Interested readers may wish to approach manufacturers in the first instance. Some source documents are listed in Section 2.2 of Chapter 2.

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bibliographic database for papers of interest. A useful overview publication on selected items of alternative and conventional technology was published by the Water Research Commission (Division of Water Technology, CSIR, 1993)**.

Energy policy issues (including the use of alternative/conventional technology) have been examined by several organizations such as the following:

- Chief Directorate: Transport, Energy and Energy for Development, Department of Mineral and Energy Affairs, Private Bag X03, Lynnwood Ridge, 0040.

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* See Britz, P., 1993. 'n Eerste in die RSA vir energie, Agring, No. 11, January 1993, p. 13 - 16.

** See Division of Water Technology, CSIR, 1993. Part 1: Guidelines on the cost effectiveness of rural water supply and sanitation projects, 35 p. Part 2: Guidelines on the technology for and management of rural water supply and sanitation projects, 191 p. + app., WRC Report No. 231/1/93, Water Research Commission, Pretoria. (The report contains useful design data for rural water and sanitation systems).

- Energy Research Institute (Energy for Development Research Centre), University of Cape Town, P O Box 207, Plumstead, 7801.

- ESKOM/South African Power Systems Studies Institute/World Energy Conference (South African National Committee), P O Box 1091, Johannesburg, 2000.

- Institute for Energy Studies/Department of Physics, Rand Afrikaans University, P O Box 524, Auckland Park, 2006. (The Photovoltaic Research Group in the Department of Physics undertakes research on the design and manufacture of photovoltaic systems).

- Institute for Futures Research (Energy Unit), University of Stellenbosch, Private Bag X1, Matieland, 7602.

- Minerals and Energy Policy Centre, P O Box 395, Wits, 2050.

- Solar Energy Society of Southern Africa, P O Box 152, La Montagne, 0184.

- South African Wind Energy Association, c/o P O Box 1091, Johannesburg, 2000.

- Southern African Institute of Energy, P O Box 93480, Yeoville, 2143.

12.6 Some training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas

The data on institutions or agencies presented in Table L13, reflect only those agencies with some form of proven track-record. The list is not complete, where for example, organizations offering courses on say, bookkeeping (which could well be relevant to water systems management), are not included. A full listing of each and every organization with at least one training course of possible interest (including correspondence colleges), is beyond the scope of the present publication. A further difficulty is the considerable number of agencies which have been established in the last three years (and continue to be established) and which cater for very specific geographic areas, or offer a very general training programme. A few such organizations, often established with a degree of fanfare,

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994.

Institution	Details of courses/activities
More formal training institutions	
Africa Enterprise, P O Box 647, Pietermaritzburg, 3200	The organization offers the (recently developed) Diploma in Social Empowerment. The diploma provides students with a foundation in development skills and theory, based on Christian principles of faith, human interaction and justice. The course has relevance to water and sanitation
Baynesfield Training Centre, P O Baynesfield, 3770	Plumbing, bricklaying, plastering, carpentry, welding (arc and gas), 6M for farm staff, 6M appreciation for farmers, 6M simulation (concepts of farm business operation for first line management), farm-business management for farmers, basic principles of supervision for supervisors
Forestry Training Services, P O Box 11, Baynesfield, 3770	Farm foreman, supervisor and management training
KwaZulu Training Trust, P O Box 10094, Ashwood, 3605	Effective committees workshops, metalwork and welding (arc and gas), building contractor training, informal sector business management and various advanced business courses
Midlands Community College, P O Box 40, Nottingham Road, 3280	Irrigation, labour relations, farm clerk, bricklaying, blocklaying and welding (arc and gas)
Mjindi Farming Training Centre, P O Box 28, Jozini, 3969	Irrigation, 6M, advanced 6M, supervision, financial planning, planning of labour, communication, labour motivation, labour relations and principles of small business
Mkondeni Training Centre, P O Box 12130, Oribi, 3205	Welding (arc, gas and metal inert gas), bricklaying, industrial safety procedures, introduction for supervisors, supervisory course, basic stores course, management courses, industrial relations, report writing, basic accounting and communication
Natal Training Centre, P O Box 912, Pinetown, 3600/ P O Box 2754, Pietermaritzburg, 3200/P O Box 637, Ladysmith, 3370. Satellite centres at: Bergville, Dundee, Scottburgh, Stanger, Umlazi and Weenen	Turning, plastering, bricklaying, hand skills (metal), welding (arc and gas), electrician's assistant, repairshop assistant, pipe fitting, small plant preventative maintenance, 6M simulation, storeman, principles of supervision and advanced supervision and worker representative skills

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994 (continued).

Institution	Details of courses/activities
Less formal training ("on-the-job" instruction)	
Africa Co-operative Action Trust-Southern Africa, P O Box 2763, Pietermaritzburg, 3200	Much of the training undertaken at five centres (Ndaleni - Richmond; Crystal Springs - Lidgetton; Nyangwini - Port Shepstone; Nsingwini - Manzini and Umsunduze - Ndwedwe) is aimed at agricultural production and related skills. On site spring protection and concrete reservoir construction training is provided in the rural areas
Bekimpilo Trust, P O Box 1135, Westville, 3630	Largely involved with health education and health care at schools in high density peri-urban areas in KwaZulu (mainly the environs of Durban). Health education includes water and sanitation issues
Bridge Foundation, P O Box 11396, Dorpspruit, 3206	The Foundation provides various engineering, agricultural and town/regional planning services mainly in the rural areas. On-the-job training is undertaken in spring protection and the drilling of wells, with on site training in committee liaison and financial management (including bookkeeping)
Built Environment Support Group, University of Natal, Private Bag X10, Dalbridge, 4014	The Group concentrates on urban townships in the Durban-Pietermaritzburg area. Broad settlement (infrastructure) upgrading is undertaken with specific reference to planning, costing of projects and project management. In terms of sanitation, the Group undertakes training of black contractors with regard to VIP toilet construction. Future plans include the training of black contractors for water systems (reticulation) installation
Centre for Low Input Agricultural Research and Development, University of Zululand, Private Bag X1001, KwaDlangezwa, 3886	Mainly engaged in agricultural training and extension in northern KwaZulu. Some on site technical training is undertaken with regard to wells and VIP toilet construction
Edendale Lay Ecumenical Centre, P O Box 63, Plessislaer, 3216	Mainly involved with agricultural and related training. Some technical training is provided for spring protection, ferro-cement tank construction and VIP toilet installation. Various courses are presented on the organization and management of co-operatives, as well as leadership skills

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994 (continued).

Institution	Details of courses/activities
Farmer Support Group, University of Natal, Private Bag X01, Scottsville, 3209	The Group is currently developing an integrated (holistic) catchment management strategy for the Mlazi and Sterkspruit River catchments above the Shongweni Dam. The (Nt)Shongweni Catchment Management Programme aims to provide a model for community participation in catchment management which can be used elsewhere in South Africa
Federation of Women's Institutes of Natal and Zululand in association with the Natal and KwaZulu Zenzele Women's Association, P O Box 153, Pietermaritzburg, 3200	Mainly involved with home-orientated courses including health and hygiene. The Federation assists with the purchase of galvanized iron rainwater tanks for schools and creches as well as training for very basic latrine improvements (not VIP toilets)
Helwel, Private Bag 802, Melmoth, 3835	Mainly involved with agricultural training. Courses are also offered on community development issues, leadership, communication, basic bookkeeping, financial planning and organizational skills, as well as concrete block making
Insika Rural Development Association, P O Box 2092, Empangeni, 3880	Mainly involved with agricultural activities. Courses are presented on organizational and leadership skills and project management skills
Institute of Natural Resources, University of Natal, Private Bag X01, Scottsville, 3209	Involved with community development and training across a broad spectrum, with major emphasis on agriculture, water supplies and sanitation in rural and peri-urban areas. The Institute is concerned with technology transfer with regard to water and sanitation and not on site training per se. A technical manual is available for the construction of the Phungalutho toilet developed at the Institute. A technical manual is also available for the repair of rusted galvanized iron rainwater tanks. A technical manual will shortly be released on the construction of 30 000 - 50 000 ℓ pre-cast concrete reservoirs
Khuphuka, P O Box 32557, Mobeni, 4060	Mainly involved in the Durban townships. The organization concentrates on technical training including metal fabrication, bricklaying, block making, plastering, plumbing, carpentry, electrical reticulation installation/repairs and welding. Theoretical training is undertaken at the main office, with on site training in the townships

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994 (continued).

Institution	Details of courses/activities
Lima Rural Development Foundation, P O Box 93, Umzumbe, 4225	Largely involved with farmer support programmes in the Natal South Coast area. Training is provided in bookkeeping and record keeping skills. Future plans include technical training and assistance with spring protection and VIP toilet construction
National Progressive Primary Health Care Network, P O Box 3840, Durban, 4000	Mainly concerned with health education, including the establishment of health committees and training of such committees in financial management. General training is provided on health issues which includes aspects of water and sanitation
Olive Information Service, 21 Sycamore Road, Durban, 4001	The agency is involved with the training of non-government organizations in general administrative and organizational skills, for effective project management (which could include water and sanitation programmes)
Operation Hunger, P O Box 37352, Overport, 4067	Largely involved with agricultural training in central and northern KwaZulu. Courses on concrete block making are offered at various sites in KwaZulu. Field training is provided in spring protection
Rural Foundation (Natal/KwaZulu Region), P O Box 931, Vryheid, 3100	Involved with the training of farm staff in various personal skills such as the 6M course. Courses are also offered on labour relations, personnel management, workers' committees, liaison committees, communication and health (including basic primary health care)
South Africa Opportunities Industrialization Centres, P O Box 11251, Dorpspruit, 3206	Involved with technical training in carpentry, electrical wiring, arc welding, painting, plastering, plumbing, bricklaying and concrete block making. Courses are also offered on primary health care, communication, small business development skills and management/planning skills for non-government organizations
South African Red Cross Society (Natal Region), P O Box 1680, Durban, 4000	Mainly involved with health and nutrition training including basic first aid and primary health care, as well as concrete block making. Some training in water and sanitation is provided in rural areas. The Society also undertakes important disaster relief work, for example, after major flooding
Sunflower Projects, P O Box 26250, Isipingo Beach, 4115	Involved with both formal and informal on-the-job technical skills training. Courses include bricklaying, block and brick making, carpentry, roofing, plastering, floor screeding, plumbing and drainage, gas cutting and welding, steel-fixing and electrical skills

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994 (continued).

Institution	Details of courses/activities
Thuthuka, P O Box 4078, Durban, 4000	Mainly concerned with the implementation of rural water supply schemes, with relevant on-the-job training in terms of management and technical skills
Turn Table Trust, P O Box 176, Himeville, 3256	The Trust concentrates on agricultural training near Bulwer. Some on site training is provided for spring protection and soil conservation
Umgeni Water, P O Box 9, Pietermaritzburg, 3200	Umgeni Water is involved with numerous water supply projects mainly in the Durban-Pietermaritzburg area. On site technical training is provided during installation (using locally recruited labour)
Valley Trust, P O Box 33, Botha's Hill, 3660	The Trust is involved with a wide range of training and development activities in the Mgeni Valley part of KwaZulu, with specific reference to socio-economic issues. Consequently, health, agriculture, water supplies and sanitation receive major emphasis. On site technical training (in the Mgeni Valley) as part of the course work is undertaken for rainwater systems, spring protection and VIP toilet construction. Trainees are drawn from many parts of South Africa. Training courses are also provided for office bearers of development committees and water committees
World Vision of Southern Africa, P O Box 17364, Congella, 4013/ Emmaus Community Project, Private Bag X16, Winterton, 3340	World Vision provides on site training with regard to agriculture, nutrition and water supplies (specifically spring protection and ferro-cement reservoir construction), as well as VIP toilet construction. Numerous such systems have been completed in many rural areas of KwaZulu
Government organizations Amatikulu Primary Health Centre, KwaZulu Department of Health, Private Bag X2113, Nyoni, 3802	The Department undertakes the training of village health workers at the Amatikulu Centre. Village health workers are employed in various rural areas in KwaZulu in a facilitation and advisory capacity. Some technical training is provided by the Centre on spring protection, aspects of well drilling, and VIP toilet construction

Table L13: Specific training agencies in Natal/KwaZulu, with relevance to water and sanitation in black settled areas, 1994 (continued).

Institution	Details of courses/activities
Community Services Branch, Natal Provincial Administration, Private Bag X9037, Pietermaritzburg, 3200	The Community Services Branch has three directorates concerned with water (and sanitation) development work. The Directorate of Community Development is mainly involved with rural and peri-urban areas under the control of the Natal Provincial Administration. On site training is provided for spring protection and VIP toilet construction. The Directorates of Physical Development - Region 1 and Region 2, are more concerned with overall physical planning (including water and sanitation), largely with reference to major peri-urban and urban settlements in the Durban-Pietermaritzburg area. The two directorates make use of consulting engineering firms and virtually no training is undertaken, other than certain basic maintenance functions
Department of National Health and Population Development, Private Bag X54318, Durban, 4000	The Department is involved with a wide range of health and nutrition services and programmes, including water and sanitation issues
KwaZulu Department of Agriculture and Forestry, Private Bag X05, Ulundi, 3838, with four regional offices in Eshowe, Ladysmith, Nongoma and Pietermaritzburg	The Department is involved with agricultural and forestry training and extension throughout KwaZulu. The Department is also responsible for water supplies in non-urban areas of KwaZulu. One of the important functions of the Department is spring protection and concrete reservoir construction, using Departmental construction teams. Limited on site technical training is provided, mainly with reference to maintenance. The Department also installs wells and boreholes plus more advanced reticulation systems, using Departmental construction teams and/or private firms. Again, limited on site training relating to basic maintenance is provided. The Department also constructs small dams for irrigation and stock watering purposes, and designs and installs irrigation systems. The Department is likewise responsible for soil erosion control works and contour bank construction
KwaZulu Department of Works, Private Bag X03, Ulundi, 3838	The Department provides water and sanitation services in large peri-urban and urban areas of KwaZulu, as well as at Government buildings (for example, clinics) in rural areas. Most construction work is undertaken by consulting engineering firms. Some facilities such as water purification works are now managed by private firms on an agency basis. Virtually no on site training (other than of extant staff) is provided

Source: (i) After Alcock, P.G., 1991. Agricultural/forestry training and extension in Natal/KwaZulu: an overview of development-orientated activities, DSRG Working Paper No. 16, Development Studies Research Group, Department of Economics, University of Natal, Pietermaritzburg, 99 p.

(ii) Fieldwork.

See also: (i) Anonymous, 1990. Business resource directory South Africa - 1990: a tool for the developing business sector, Get Ahead Foundation, Pretoria, 45 p. + app.

(ii) Anonymous, 1990/1992. A directory of short courses in Durban and some other areas in Natal, Career Information Centre, Durban, 86 p.

(iii) Anonymous, 1991. Bridge 1991, Human Awareness Programme, Grant Park, 308 p. (The publication is regularly updated).

Note: (i) The data in the table reflect the current (1994) situation. The KwaZulu Training Trust (see above), is planning to provide several water and sanitation management training courses and modules in the near future.

(ii) A National Community Water and Sanitation Training Institute has been established at the University of the North, Private Bag X1106, Sovenga, 0727. The Institute will undertake the training of trainers in relevant skills as well as the direct training of community water and sanitation committees. Research will be undertaken on adult education with respect to water and sanitation issues. It is envisaged that the Institute will in due course establish water and sanitation training centres elsewhere in South Africa.

(iii) The recently formed Durban Metro Water, P O Box 1038, Durban, 4000, has established a plumbing school where a restricted plumbers course, as well as a water-service hand course is available for suitable peri-urban and rural trainees. Skills taught include pipe laying, trenching, backfilling; and the maintenance of valves, pipes and taps.

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have subsequently withered away or have amalgamated with other non-government organizations. It would be pointless to include these organizations in Table L13.

Tertiary institutions undertaking training (at an advanced level), and which could or do impact on water and sanitation systems management include the universities of Durban-Westville, Natal and Zululand; the technikons Mangosuthu, M L Sultan and Natal; the Cedara College of Agriculture, and the 24 technical colleges in the province. The latter are: Cato Manor, Durban, Durban Central, L C Johnson, Ntuzuma, Sivananda, Swinton

Road and Umlazi (Durban); Pinetown (Pinetown); Enyenyezi and Port Shepstone (Port Shepstone); Richards Bay (Richards Bay); Nongoma (Nongoma); Ezakheni and Ladysmith (Ladysmith); Madadeni, Newcastle and St Oswald's (Newcastle); Edendale, KwaZulu-Natal Midlands, Msunduzi, Northdale and Plessislaer (Pietermaritzburg), and Vryheid (Vryheid). The more formal agricultural/forestry/industrial training institutions which offer courses including those of some relevance to water and sanitation are: Africa Enterprise; the Baynesfield Training Centre; Forestry Training Services (formerly Timber Industry Manpower Services); the KwaZulu Training Trust; the Midlands Community College; the Mjindi Farming Training Centre; the Mkondeni Training Centre, and the Natal Training Centre. A feature of the courses presented by certain training institutions such as the Baynesfield Training Centre, is the 6M course. The purpose of the 6M (manpower, management, money, machinery, materials and markets) course is to provide trainees with some background to the functioning of a modern economy. The 6M course - while not specifically related to water issues - serves as a valuable introduction which has widespread management implications.

Some 25 other agencies undertake general development-work training, sometimes with special reference to water and sanitation (such as spring protection). Government departments involved with water and sanitation training include the Community Services Branch of the Natal Provincial Administration; the Department of National Health and Population Development; the KwaZulu Department of Agriculture and Forestry; the KwaZulu Department of Health, and the KwaZulu Department of Works. Certain other organizations such as the Natal Parks Board undertake a facilitation role by bringing the major role-players together, in order to promote development projects (including small water and sanitation systems) in rural areas. A number of consulting engineering firms operating in terms of Government contracts, are likewise involved with the provision of water and sanitation services which include training aspects. A few private individuals sometimes attached to local church initiatives, are also active with the installation of water and sanitation systems in rural areas. Training is provided in a number of instances.

12.7 Types of informal settlement in Natal/KwaZulu

A spatial typology of informal settlements with particular reference to the Durban Functional Region is presented in Table L14. It should be noted - with the exception of the more traditional rural settlements - that the typology is not static and describes stages in the evolution of informal settlements, as part of an overall urbanization process. Various factors including population influx and economic conditions will influence the speed of transition from one category to another, in any given geographic area. A broad distinction can be drawn between informal settlements which are mainly rural-orientated and those which are largely urban-orientated (Haarhoff, 1984)*. A significant proportion of the population in the Durban Functional Region live in urban informal settlements, with consequent needs inter alia for improved water supplies, sanitation and solid waste removal. Protected springs and boreholes with handpumps are probably the best interim method of upgrading water supplies in the traditional, betterment and modernising rural settlements (depending on population density). Reticulated water systems however, as well as VIP toilets or other appropriate sanitation systems are required in the more densely settled, urban-orientated communities.

A typology of social circumstances in the large informal urban fringe surrounding Durban is outlined in Table L15. The table provides some background for a more detailed understanding of the problems involved in the provision of infrastructure in major metropolitan areas. It is possible for example that agreements for the supply say, of reticulated water, to an area consisting mainly of newly arrived workseekers from the rural areas (category 8), could be fraught with difficulties. (The workseekers may not necessarily be familiar with the concept of regular payments for improved water supplies). Much would depend on the degree of co-operation received from landlords/tenants. Other difficulties can include a rapidly increasing population and accordingly, water demand (and hence design) problems. Similarly problematic is the need for improved sanitation - where population densities may be higher than at first envisaged - resulting in an overload on systems including VIP toilets. (The capacity of the VIP pits may soon be exceeded, especially in shallow Mispah soils)**. In essence, considerable foresight as well as accurate demographic data is necessary for the proper planning and installation of efficient services in urban areas. "Learning curves" for both suppliers and consumers of services are still required, although several important lessons were derived in the years of the KwaZulu/Natal Planning Council and subsequently the RSA-KwaZulu Development Project.

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* See Haarhoff, E.J., 1984. A spatial analysis of African urbanization and informal settlement in Natal/KwaZulu, Ph.D. Thesis, Department of Town and Regional Planning, University of Natal, Durban, 312 p. + app.

** The various types of soils in South Africa are discussed in the chapter on soils and soil erosion, elsewhere in this publication.

Table L14: A spatial typology of informal settlement patterns in Natal/KwaZulu, with special reference to the Durban Functional Region.

Category	Description
1. Traditional rural settlements	All dwellings consist of traditional kraals, or at least 75% of kraals are traditional, with the balance comprising "modernised" (rectangular) kraals. The smallest unit is the kraal or homestead ("umuzi"), occupied by the household head and family. The household is composed of a number of separate dwelling units (huts) generally arranged in a circular fashion. In addition to land occupied by the kraal site, rights are granted for the cultivation of land (housefields). Agricultural activity consists largely of subsistence farming
2. Rural betterment settlements	"Betterment" refers to the re-organization of kraals into compact villages, with the remaining land allocated and developed for more productive agricultural uses (the main aim of betterment). Considerable attention in the betterment programme was given to concentrating households in defined residential areas, usually on land with a low agricultural potential. The policy is not generally considered to have been a success. (See the chapter on soils and soil erosion)
3. Modernising rural settlements	Comprise settlements similar in layout to traditional rural settlements, where degrees of modernisation are in the process of influencing housing type and spatial arrangement. These settlements consist of both traditional and modernised kraals, although traditional kraals still exceed 50% of the total. The settlements are found beyond a 30 km radius of the urban core areas, with low densities similar to traditional settlements (<2 dwellings ha^{-1}). There is often evidence of commercial agricultural activities
4. Modernised informal settlements	The spatial organization of such settlements is similar to the above category. Three dwelling types are found namely, traditional kraals ($<25\%$ of the total), modernised kraals, and an increasing proportion of informal dwellings (shacks). These settlements are generally closer to the urban core areas, with gross densities of 2 - 4 dwellings ha^{-1}. Due to the proximity of the urban core, there is a greater dependence on formal urban employment, with reduced agricultural activities

Table L14: A spatial typology of informal settlement patterns in Natal/KwaZulu, with special reference to the Durban Functional Region (continued).

Category	Description
5. Incipient urban informal settlements	In these settlements, both modernised kraals and informal dwellings are found. Over 50% of dwellings are of the informal type, with an increasing proportion of informal housing evident with the passage of time. Land used for agricultural production (subsistence and commercial) tends to be replaced by informal residential uses. The settlements are located within 30 km of the centres of major metropolitan areas. The settlements have a gross density of 4 - 6 dwellings ha^{-1}, and represent an early stage in the development of urban informal settlements on the peri-urban fringes of metropolitan areas. Most such areas are in KwaZulu where customary methods of land allocation still operate, thereby influencing the spatial organization of dwellings. Land in close proximity to bus routes is developed to a greater extent than more remote land. Economic activity is predominantly urban-orientated
6. Urban informal settlements (known locally as "mjondola" settlements)	In these settlements, nearly all dwellings (75%) are of the informal type. They are generally referred to as squatter settlements. The gross density of the settlements exceeds 6 dwellings ha^{-1}. The settlements are situated in close proximity to the metropolitan areas, and are characterized by problems of inadequate water supplies and sanitation as well as solid waste accumulation. Given the effects of drought and violence, plus the "bright lights" factor (the lure of urban life and potential economic advancement), such settlements are subject to rapid population increases especially in the Durban Functional Region. The lodging of tenants or members of the family is common

<u>Source</u>: After Haarhoff, E.J., 1984. A spatial analysis of African urbanization and informal settlement in Natal/KwaZulu, Ph.D. Thesis, Department of Town and Regional Planning, University of Natal, Durban, 312 p. + app.

<u>Note</u>: (i) Occupancy rates of the settlement categories are influenced by various socio-economic factors, dwelling type and geographical locality. The settlement densities (dwellings ha^{-1}) data may not reflect <u>current</u> trends in the Durban Functional Region, in view of high in-migration patterns as well as land invasions. It has been found, for example, that many informal households live in high density zones (up to 86 shacks or families ha^{-1}). As many as 18 people have been observed living in shacks the size of a single garage. Shacks built in very rugged terrain (land steeper than 1 : 2), are also evident in the Durban Functional Region (Stewart, 1994)*.

* See Stewart, P., 1994. DIY housing, <u>Developer</u>, VOL 9, November 1994, p. 20 - 22.

(ii) According to Byerley and McIntosh (1994)* urban informal settlements in Natal/KwaZulu can be divided in a spatial sense into six categories, namely: shack settlements on tribal land; shack settlements on black freehold land; shack settlements in townships; backyard shacks in townships; settlements on State owned land, and settlements on white smallholdings or farms on the urban fringe. The emergence of shack settlements close to and in major urban areas has resulted in an additional category (suburban shack settlements). Temporary pavement dwellers in the main cities of Natal/KwaZulu constitute a new type of "settlement".

(iii) According to data quoted in Cooper, Hamilton, Mashabela, Mackay, Sidiropoulos, Gordon-Brown, Murphy and Markham (1993)**, the population of South Africa as of 1992, was some 39 381 000 people (entire land area of South Africa). A total of 2 641 000 people was resident in Natal per se, with 5 378 800 people resident in KwaZulu per se. The total black population of Natal/KwaZulu was 6 465 500 people. The population density in Natal (in 1992), was 47,7 people km^{-2} with 149,1 people km^{-2} in KwaZulu. The annual population growth rate in South Africa (as a whole) during the 1970s was 3%, decreasing to 2,6% during the 1980s. The mean population growth rate in the 1991 - 1992 period was 2,4% (2,8% for blacks). Estimates of the South African population by the year 2000, vary from 44 - 51 million people, rising to 53 - 66 million people by the year 2010. Approximately 63% of the population of South Africa (or 22 million people), was urbanized by 1990, rising to 33 million or 75% of the total population by the year 2000. The rural population is expected to decline from 16 million in 1990, to 15 million in the year 2000.

(iv) Some 4 million people (of all race groups) were resident in the Durban-Pietermaritzburg Metropolitan Axis in 1990, of whom 50% lived in informal settlements on the peri-urban fringes. More than half of the total population of Natal/KwaZulu was urbanized in 1992, while more than 50% of the entire Natal/KwaZulu population is likely to be resident in the Durban Functional Region alone by the year 2000. Blacks presently constitute 75% of the total urban population of Natal/KwaZulu. Rapid urbanization was responsible for a virtual doubling of the population of the Durban Functional Region in the

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* See Byerley, M. and McIntosh, A., 1994. Chapter 14. Administration of urban informal settlements, In: Hindson, D. and McCarthy, J. (eds), Here to Stay: Informal Settlements in KwaZulu-Natal, Indicator Press, Durban, p. 167 - 176.

** See Cooper, C., Hamilton, R., Mashabela, H., Mackay, S., Sidiropoulos, E., Gordon-Brown, C., Murphy, S. and Markham, C., 1993. Race relations survey 1992/93, South African Institute of Race Relations, Johannesburg, 708 p. See also, Erasmus, J., 1991. Economic and social memorandum, Region E, Centre for Information Analysis, Development Bank of Southern Africa, Halfway House, 107 p., as well as May, J., 1993. Economic development strategies for Region E: Phase 1 - socio economic analysis and assessment: working document for input into synthesis report - demography and social concerns, Regional Development Advisory Committee - Region E, Pietermaritzburg, 31 p. + app. See in addition: Anonymous, 1995. ESKOM strategic plan: final demographic perspective report, Seneque Smit and Maughan-Brown, Durban, 72 p. + app.

period 1970 - 1980. Some 320 000 shacks in informal settlements in the region need to be replaced with serviced sites or upgraded. Approximately 300 000 new dwelling units are likewise required in the Durban Functional Region in the next 10 years*. Overall, Natal/KwaZulu constituting 8% of the land area of South Africa, is home to 21% of the total South African population (Cooper et al, 1993).

(v) According to Wilkins and Hofmeyr (1994, quoted in Hindson and McCarthy, 1994)** the estimated distribution of the black population in Natal/KwaZulu in 1992 was as follows: formal settlements in the Durban-Pietermaritzburg Metropolitan Axis (24,7%); formal settlements in or adjacent to small and medium towns (3,8%); informal settlements in the Durban-Pietermaritzburg Metropolitan Axis (16,7%); informal settlements in or adjacent to other towns (5,1%), and transitional urbanizing settlements in rural areas (4,3%). The total urban settlement component was 54,6% with the remainder of the black population resident in rural areas. Problems of definition are always apparent in such estimates. Hindson and McCarthy observed that for densely inhabited transitional settlements in rural areas, it is not clear where the "rural" landscape ends and a dense "rural settlement" begins.

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* Such information may be incorrect. Surveys undertaken in 1995/96 in the **Durban Metropolitan Area,** by the Information Branch of the Urban Strategy Department (Durban Corporation), imply that previous population data for the Metropolitan Area have been overestimates and that there are approximately 1 200 000 residents fewer than estimated. (Note that the Durban Metropolitan Area covering 1 300 km^2 is somewhat smaller than the Durban Functional Region). Less people per dwelling and a trend towards smaller nuclear families (termed decompression as opposed to compression), was evident from the survey data. A smaller population and a reduced population growth rate (especially in the peri-urban areas and in the informal settlements), has obvious implications for infrastructure delivery and health services. Some of the survey data are available in a Geographic Information System (GIS) database. May (1993 - above) has also questioned the accuracy of regional population statistics, as well as estimates of the entire South African population.

** See Hindson, D. and McCarthy, J., 1994. Chapter 1. Defining and gauging the problem, In: Hindson, D. and McCarthy, J. (eds), Here to Stay: Informal Settlements in KwaZulu-Natal, Indicator Press, Durban, p. 1 - 28., as well as Graaff, J.F. de V., 1987. The present state of urbanization in the South African homelands: rethinking the concepts and predicting the future, Development Southern Africa, VOL 4(1), p. 46 - 66., plus Todes, A., 1994. Urbanization and urban management in KwaZulu Natal, Development Southern Africa, VOL 11(4), p. 541 - 555. See in addition: Geyer, H.S. and Du Plessis, D.J., 1994. Existence level differences and spatial industrial restructuring in South Africa: RDP imperatives, Development Southern Africa, VOL 11(4), p. 599 - 616., and Dewar, D., 1994. Reconstructing the South African countryside: the small towns, Development Southern Africa, VOL 11(3), p. 351 - 362. A useful overview of urbanization is the following: Gelderblom, D. and Kok, P., 1994. Urbanization: South Africa's Challenge, VOL 1: Dynamics, HSRC Publishers, Pretoria, 318 p., as well as Kok, P. and Gelderblom, D., 1994. Urbanization: South Africa's Challenge, VOL 2: Planning, HSRC Publishers, Pretoria, 334 p.

Table L15: A typology of social categories in the informal urban fringe surrounding Durban.

Category	Description
1. Original or earlier settlers: owners	Such a population group with a rural orientation, has traditional land tenure rights and comprises 10 - 15% of the total population in the urban fringe. This home-owning group is a relatively affluent social elite, occupying larger sites and with the resources to develop the sites. The residents are permanent with children likely to be formally employed. Some houses are occupied by the children of these early settlers
2. Original or earlier settlers: landlords	This permanent group comprising some 5 - 7,5% of the total urban fringe population, shares many characteristics with the first group. A major difference is the presence of shack-dwelling tenants ("shack-farming") on their properties, as a means of increasing income and status. The group tends to have high prestige and social/ political power, although they are sometimes resented
3. Urban overspill: tenants	The group forming 20 - 25% of the urban fringe population, consists of permanent residents often employed in the formal sector. The group is composed inter alia of the children of residents in formal townships who cannot find accommodation, or township residents requiring larger, cheaper or more flexible accommodation. There is a desire to return to the formal townships if suitable accommodation is available. This category includes householders who may have a house in a formal township, but who need other accommodation for a second wife or relatives from a rural area
4. Urban overspill: female tenants	This permanent category is essentially the same as the above, comprising 10 -15% of the urban fringe population. The group consists primarily of households headed by women including older widows, divorcees, or unmarried mothers unable to find accommodation in a formal township. Also included in this group are some professional women such as nurses

Table L15: A typology of social categories in the informal urban fringe surrounding Durban (continued).

Category	Description
5. Established peri-urban tenants	Such a population group consists of people who have almost by tradition lived in informal areas (including many ex-Cato Manor residents who refused to move to KwaMashu after the clearance of Cato Manor in the 1960s). Some residents shift from place to place depending on circumstances, although they are permanent in the general area. These residents have been termed "peri-urban mobiles". The group as a whole, comprises some 10 - 20% of the urban fringe population
6. Displaced or urbanizing rural families	This group (5 - 10% of the total fringe population), consists of younger families from white farms as well as rural areas of KwaZulu, or families displaced from (previous) resettlement areas. These families are forced out by economic pressures including landlessness, or a feeling of marginality (with reference to the rural areas). The families are probably permanent in peri-urban areas, although they may wish to return to the rural areas in the long term. Some of the group form a sub-tenant class
7. Ex-hostel migrants	The group forming 5 - 15% of the urban fringe are mainly sub-tenants. The group consists of migrant workers who find hostel life unattractive, those who wish to acquire a common law wife/ girlfriend, and those who wish to settle permanently. (The latter category may bring their rural families to live with them for long periods or even permanently). The group erect shacks or rent rooms on a sub-tenancy basis, usually in crowded areas near transport routes. Members of the group are often employed in the formal sector. Not all members aspire to a permanent urban lifestyle, although economic necessities may dictate long periods of residence until retirement. The latter sub-group accordingly, has a tendency to seek shack accommodation as an "interim" solution
8. Workseekers from the rural areas: sub-tenants	The group is much the same as the above category, comprising 5 - 10% of the urban fringe population. The group includes many people from Pondoland in the Transkei. Most of the group survive on informal sector activities. Some members are permanent, some are permanent until retirement, while others are transient

Table L15: **A typology of social categories in the informal urban fringe surrounding Durban (continued).**

Category	Description
9. Lumpenproletariat	This group is permanent or moves from area to area and comprises less than 5% of the urban fringe. The group consists of tenants and sub-tenants, and is an assorted category of social or economic refugees including beer-brewers, pickpockets and prostitutes

Source: After Schlemmer, L. and Møller, V., 1982. Informal peri-urban communities and planning needs, CASS Report No. 38/82, Centre for Applied Social Sciences, University of Natal, Durban, 32 p.

See also: Schlemmer, L., 1985. Part 2: Influx control, black urbanization, migrants and squatters. Chapter 12. Squatter communities: safety valves in the rural-urban nexus, In: Giliomee, H. and Schlemmer, L. (eds), Up Against the Fences: Poverty, Passes and Privilege in South Africa, David Philip Publisher, Cape Town, p. 167 - 191.

Note: The individual categories constitute an overview. There is a variety of social types and accommodation arrangements. These range from the traditional allocation of land by a chief to the renting of sites by landholders or occupiers; the sub-letting of sites by tenants, and the renting of rooms or shacks by landholders and tenants. The proportions of the various categories are estimates only.

12.8 The size of households in black settled areas of Natal/KwaZulu

Accurate information on the size of households and the overall population in black settled areas is an important design parameter for water supply and sanitation planning. Such data are available from the population census which is conducted at intervals by the

Central Statistical Service in Pretoria*. Various guesstimates are also found in the literature, especially in consulting engineering as well as town and regional planning firms' reports. Other sources of population information are listed in Table L16.

The household size data presented in Table L17, refer to a large socio-economic survey of several thousand households, which was undertaken in 1992 in all 26 magisterial districts of KwaZulu (May, 1993)**. Settlements examined included dispersed rural communities; densely settled rural communities; rural villages; formal townships adjacent to smaller centres in Natal; peri-urban informal settlements; formal townships adjacent to metropolitan centres in Natal; densely settled shack settlements, and shack in-fill settlements.

Considerable difficulties were sometimes experienced with regard to the number of people sleeping at the "household" each night. For the purposes of the survey, a household was defined as those people who usually contribute towards and eat from a common "cooking pot", and who have a common set of domestic and economic ties (although they may be absent from the household for varying periods of time). The range in mean residents per household - for all 63 settlement sites examined in the survey - was 5,07 - 9,72. The mean number of residents per household in urban settlements was 5,97 with a mean of 7,06 residents per household in rural settlements. The following table (Table L18), provides data on the overall mean size of households (as assessed in the 1992 survey) for the 26 districts of KwaZulu.

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* The Central Statistical Service, Private Bag X44, Pretoria, 0001, publishes a quarterly User's guide, which lists all currently available reports and statistical (news) releases (including census data) produced by the Service. A bibliography is also available. See: Anonymous, 1995. Statibib: list of CSS publications as from 1978, Central Statistical Service, Pretoria, 179 p. All legal deposit libraries maintain a comprehensive collection of Central Statistical Service publications. See for example, Anonymous, 1992. Geographical distribution of the population, with a review for 1970 - 1991, CSS Report No. 03-01-02, Central Statistical Service, Pretoria, 258 p. (The report, one of 26 such reports, refers to the 1991 census. Census survey data are also available on magnetic tape). A series of provincial reports containing valuable demographic, socio-economic and economic data for all the new provinces in South Africa, plus South Africa as a whole, has been initiated by the Central Statistical Service. In terms of demography, the reports contain data for instance, on the population distribution in all the magisterial districts, as well as data on household size and the number of rooms per dwelling. Important information is also provided on the source of domestic water supplies as well as methods of sanitation and refuse disposal - discussed in the chapter on health. The publication series will be updated on an annual basis. See: Anonymous, 1994. Provincial statistics 1994, Part 5: KwaZulu/Natal, CSS Report No. 00-90-05 (1994), Central Statistical Service, Pretoria, 99 p.

** See May, J., 1993. Data-base of household size by settlement: KwaZulu -1992, Working Document, Data Research Africa cc, Durban, 11 p.

Table L16: Some sources of population data in Natal/KwaZulu, with special reference to the Durban Functional Region.

Institution	Address
Central Statistical Service	Private Bag X54337, Durban, 4000
Chief Directorate: Local Government, Community Services Branch, Natal Provincial Administration	Private Bag X9037, Pietermaritzburg, 3200
Development and Services Board	P O Box 416, Pietermaritzburg, 3200
Development Bank of Southern Africa	P O Box 1234, Halfway House, 1685
Durban Corporation City Engineer's Department Durban Metropolitan Transport Advisory Board	P O Box 680, Durban, 4000
Human Sciences Research Council	P O Box 17302, Congella, 4013
Inkatha Institute for South Africa	P O Box 2415, Durban, 4000
KwaZulu Government Department of Economic Affairs Department of the Interior	 Private Bag X23, Ulundi, 3838 Private Bag X02, Ulundi, 3838
Pietermaritzburg Corporation City Engineer's Department	P O Box 205, Pietermaritzburg, 3200
RSA-KwaZulu Development Project c/o Van Wyk and Louw Inc., now Africon Engineering International Ltd	P O Box 1319, Westville, 3630
Tongaat-Hulett Planning Forum c/o Tongaat-Hulett Properties Ltd	P O Box 22319, Glenashley, 4022
Umgeni Water (old supply area only)	P O Box 9, Pietermaritzburg, 3200
University of Durban-Westville Institute for Social and Economic Research	Private Bag X54001, Durban, 4000

Table L16: Some sources of population data in Natal/KwaZulu, with special reference to the Durban Functional Region (continued).

Institution	Address
University of Natal, Durban Built Environment Support Group Centre for Social and Development Studies Department of Architecture Department of Economics Department of Geographical and Environmental Sciences Department of Surveying and Mapping Department of Town and Regional Planning	Private Bag X10, Dalbridge, 4014
University of Natal, Pietermaritzburg Department of Geography Institute of Natural Resources	Private Bag X01, Scottsville, 3209
University of South Africa Bureau of Market Research	P O Box 392, Pretoria, 0001
Consultative Business Movement (incorporating the defunct Urban Foundation)	P O Box 3895, Durban, 4000

Source: Fieldwork.

Note: (i) The Durban City Engineer's Department has been divided into a number of component departments and units. The term "City Engineer's Department" - with reference to Durban - is used here and elsewhere in this publication, in a generic sense.

(ii) A useful source document is the following: Pennington, S., Pennington, R. and Mackay-Coghill, N., 1990. The South African township annual, Industrial Relations Information Surveys, Johannesburg, various pages. (The publication, issued annually, contains data on several townships including some in Natal/KwaZulu, namely, the Edendale Valley complex adjacent to Pietermaritzburg, as well as the townships of Inanda, Lindelani, KwaMashu and Umlazi near Durban, and Esikaweni near Empangeni. Numerous township statistics are presented including population, the number of formal and informal dwellings, and occupancy rates. Brief data are also provided on services such as water and sanitation. The 1991 edition includes information on Osizweni near Newcastle).

(iii) The Bureau of Market Research (University of South Africa), regularly compiles detailed reports on regional and national population estimates (see the bibliographic database).

(iv) The Tongaat-Hulett Planning Forum produced three core reports on planning in the Durban Functional Region*. The reports are a valuable source of information. A brief overview can be found in Anonymous, 1991. Looking ahead: the Tongaat-Hulett Planning Forum, Developer, No. 40, July/September 1991, p. 5 - 6. See also Anonymous, 1991. Scenario analysis, Developer, (same issue), p. 10 - 12.

Table L17: Household size in given settlement types in KwaZulu, 1992.

Settlement type	Number of households examined	Mean number of household residents (as defined in the survey)
Homeland metropolitan areas	520	5,71
Homeland peri-urban areas	676	6,41
Homeland towns	1 303	6,08
Homeland rural areas	2 706	7,25
Homeland dense rural areas	756	6,96

Source: After May, J., 1993. Data-base of household size by settlement: KwaZulu - 1992, Working Document, Data Research Africa cc, Durban, 11 p.

See also: May, J., 1993. Economic development strategies for Region E: Phase 1 - socio economic analysis and assessment: working document for input into synthesis report - demography and social concerns, Regional Development Advisory Committee - Region E, Pietermaritzburg, 31 p. + app. (The problems of obtaining accurate household socio-economic data are emphasized in this report).

Note: The KwaZulu Finance and Investment Corporation Ltd, P O Box 2801, Durban, 4000, who commissioned and funded the survey, is sincerely thanked for permission to reproduce the data.

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* See Anonymous, 1989. The Durban Functional Region: planning for the 21st Century, Report 1. The current situation: executive summary, Tongaat-Hulett Properties Ltd, Durban, 33 p., and Anonymous, 1989. The Durban Functional Region: planning for the 21st Century, Report 1. The current situation: appendices, Tongaat-Hulett Properties Ltd, Durban, various pages. See in addition: Anonymous, 1990. The Durban Functional Region: planning for the 21st Century, Report 2. Scenarios for 2000: executive summary, Tongaat-Hulett Properties Ltd, Durban, 34 p., and Anonymous, 1990. The Durban Functional Region: planning for the 21st Century, Report 3. Strategy proposals for discussion with DFR stakeholders: executive summary, Tongaat-Hulett Properties Ltd, Durban, 26 p.

Table L18: Mean household size per KwaZulu district, 1992.

District	Mean number of household residents (as defined in the survey)
Emnambithi	6,23
Emzumbe	6,64
Ezingolweni	5,36
Hlabisa	8,49
Hlanganani	6,11
Ingwavuma	8,19
Inkanyezi	6,61
Madadeni	7,10
Mahlabathini	9,26
Maphumulo	6,33
Mpumalanga	6,07
Msinga	6,36
Ndwedwe	6,83
Nkandla	7,17
Nongoma	7,28
Nquthu	6,98
Nseleni	7,04
Ntuzuma	5,88
Okhahlamba	6,63
Ongoye	5,81
Simdlangentsha	7,60
Ubombo	8,49
Umbumbulu	6,54
Umlazi	5,50
Vulamehlo	5,99
Vulindlela	6,24

Source: After May, J., 1993. Data-base of household size by settlement: KwaZulu - 1992, Working Document, Data Research Africa cc, Durban, 11 p.

Note: (i) The KwaZulu Finance and Investment Corporation Ltd, P O Box 2801, Durban, 4000, who commissioned and funded the survey, is sincerely thanked for permission to reproduce the data.

(ii) Part of the Simdlangentsha District is in the Transvaal.

(iii) Additional background information in terms of the Data Research Africa project can be found in Ardington, E., 1994. Quantitative analysis of socio-economic data from five thousand households in KwaZulu: a secondary analysis of data from an income and expenditure survey conducted in KwaZulu in 1992 by Data Research Africa, CSDS Research Report No. 4, Centre for Social and Development Studies, University of Natal, Durban, 59 p.

12.9 Housing delivery methods in the black urban areas of South Africa

Four main housing delivery systems are found in South Africa (Table L19). To-date, much of the housing has been provided by the State and the private sector, and involves project initiated self-help and conventional housing delivery systems. Both the State and the private sector have prescribed the level of service and infrastructure provision. Note that the discussion refers to the situation as at 1993.

Table L19: Existing housing delivery systems and sub-systems in South Africa, 1993.

Primary system	Sub-system
1. Unaided self-help (User initiated housing, largely falling outside the existing regulatory and housing policy framework as well as the legal system)	• Informal (spontaneous) settlements No de jure land ownership rights. Land is acquired through illegal occupation and organized invasions, informal secondary markets, chiefs and indunas, the forced eviction of the de jure land owner, or through a self-appointed warlord who controls and allocates the land. Land acquisition is followed by the erection of a housing structure which is incrementally improved. Inhabitants of informal settlements may engage in collective actions designed to improve levels of service and infrastructure provision
	• Illegal sub-divisions The de jure land owner illegally subdivides the property and sells the land to a willing buyer, or rents out the land. Occasionally, the land owner takes responsibility for the supply of water

Table L19: Existing housing delivery systems and sub-systems in South Africa, 1993 (continued).

Primary system	Sub-system
1. Unaided self-help (continued)	• Backyard shacks Consist of housing constructed on the property of a formal house. Such housing is usually erected by, or with the consent of the de jure property rights owner
	• Floating squatters This group occupies a privately or publically owned space which they defend and use as their own, for example, street children who sleep on pavements, in parks and in railway stations
2. Supported self-help (This delivery system involves the upgrading of informal settlements and illegal sub-divisions, through the formalization of land tenure, the provision of services and infrastructure, and possibly a housing component)	• Emergency service provision The State provides essential services such as water, solid waste removal and some form of sanitation, pending a decision on the long term future of the area
	• "Roll-over" upgrading Usually involves the dismantling of existing housing and the resettlement of people in temporary accommodation, while services and infrastructure are provided on upgraded sites
	• Community sensitive in situ upgrading This refers to the in situ upgrading of informal settlements by an external agent such as a utility company or a local authority. A deliberate attempt is made to limit the displacement of people, with varying degrees of community consultation and participation
	• Community initiated in situ upgrading The community "owns" and "drives" the upgrading process, and enlists the technical assistance of service organizations and private sector consultants

Table L19: Existing housing delivery systems and sub-systems in South Africa, 1993 (continued).

Primary system	Sub-system
3. **Project initiated self-help** (This delivery system differs from the above methods, where the provision of a serviced site and secure tenure, precedes occupation of the site and the construction of a dwelling unit. The method mainly consists of site and service schemes implemented by the State and the private sector. Schemes are often located on the urban periphery. Existing approaches to project initiated self-help are strongly influenced by the source of funding and/or the race group in question)	• <u>Self-help projects for Coloureds and Indians</u> The House of Representatives (Coloureds) undertakes self-help housing schemes which deliver complete or nearly complete conventional housing. A standardized nationally formulated package of specifications, plans, materials and training manuals is provided by the House of Representatives. On site material depots, supervisors and trainers are found at some of the larger projects. The programme is mainly implemented by local authorities. The House of Delegates (Indians) has not delivered much housing in terms of this method, preferring to use the shell-housing concept
	• <u>Self-help projects for blacks</u> The projects are initiated by national, provincial and local authority agencies, and are the main form of State assisted housing for blacks. Most of the schemes involve serviced sites and some starter-housing. The level of services largely depends on the project initiator and the funding agency. Community participation is usually confined to the construction of the dwelling unit, with only limited attempts to provide consolidation support (for example, training plus easy access to home loans and building materials)
	• <u>Independent Development Trust sponsored projects</u> These projects involve the provision of security of tenure, services and infrastructure, in terms of the R7 500 capital subsidy allocated by the Trust. Many delivery agents have been used for the various projects

Table L19: Existing housing delivery systems and sub-systems in South Africa, 1993 (continued).

Primary system	Sub-system
4. Conventional housing (Refers to completed dwelling units constructed to nationally and locally defined building and town planning specifications. The type of housing ranges from free standing houses, to semi-detached housing and multi-storey blocks of flats)	• State rental sector Involves housing provided, allocated and managed by the State. Since 1983, some of the housing stock has been sold to occupiers, with very little new rental stock being built
	• Private rental sector Included in this category is formal rental accommodation (lodgings, domestic quarters, flats and houses) owned by a variety of groups, for example, petty landlords, pension and insurance companies and property speculators. The initiation and delivery of the housing follows a route similar to private sector provided ownership units (see below)
	• State developed ownership units This category refers to State initiated projects where the units are developed for ownership, for example, Mitchell's Plain. Initially, all activities relating to the planning, building, allocation and management of this category of housing were handled by the State. Recently, different forms of State and private sector co-operation have been used to plan, implement and finance such housing
	• Private sector provided ownership units The private sector developer is responsible for undertaking the project with the attendant risk. Serviced sites may be sold, where the owner organizes the construction of a house. Alternatively, developers may sell the site on a "plot and plan" basis, where the developer assumes the role of a building contractor with all liabilities. Another method involves the construction of houses which are sold voetstoots. All such housing is usually sold to individual buyers (with or without some form of financial assistance)

Source: After Walker, N., 1993. Chapter 4. Current approaches to low-income housing delivery, In: A New Approach to Housing Delivery: Some Ideas for Discussion, Built Environment Support Group, University of Natal, Durban, p. 18 - 38.

See also:

(i) Anonymous, 1992. Housing in South Africa: proposals on a policy and strategy, Report prepared by the Task Group on National Housing Policy and Strategy of the South African Housing Advisory Council under the chairmanship of Dr J.H. De Loor, Report No. RP 79/1992, Government Printer, Pretoria, 409 p.

(ii) Boaden, B., 1990. The myths and the realities of shack upgrading, Urban Forum, VOL 1(1), p. 75 - 84. (The paper contains a very useful overview of the difficulties involved in the process of shack upgrading).

(iii) Botes, L.J.S., Stewart, T. and Wessels, J., 1996. Conflict in development: lessons from the housing initiatives in Freedom Square and Namibia Square, Development Southern Africa, VOL 13(3), p. 453 - 467. (The paper similarly, discusses a number of pitfalls in respect of housing delivery and the provision of services).

(iv) Gilbert, A., Mabin, A., McCarthy, M. and Watson, V., 1996. A neglected sector of housing for the poor: subletting, sharing and informal renting, Development Southern Africa, VOL 13(3), p. 495 - 497.

Note:

(i) The housing backlog in Natal/KwaZulu (1990 - 2010) is estimated to be 726 000 units in the urban areas and 290 000 units in the peri-urban and rural areas. (No definitive data on the housing backlog are available, and numerous guesstimates are evident in the literature) (Van Gass, 1993, quoted in Walker, 1993 - above).

(ii) Poverty is a very real problem influencing the demand for conventional housing. Many families are simply unable to purchase formal housing stock. Inadequate services, insecurity of tenure and high rentals - especially for backyard shacks - compound the problems of the urban poor.

(iii) The variety of State and private sector agencies involved in the supply of housing effectively precludes (in most cases), uniform or standardized levels of services and infrastructure provision, even within a given area such as the Durban Functional Region.

(iv) Reservations have been expressed regarding the suitability of subsidized site and service schemes. The (previous) subsidy available per site largely covered the costs of land and the infrastructure required (for example, a VIP toilet and standpipe), leaving a very small amount for the building of a dwelling. A new scheme however, was announced in March 1994, with a subsidy of R12 500 per household earning between R801 - R1 500 a month; a subsidy of R9 500 for households earning between R1 501 - R2 500 a month, and a subsidy of R5 000 for households earning between R2 501 - R3 500 a month. A further subsidy was announced in February 1995 (backdated to March 1994), whereby a R15 000 subsidy is available for households with a combined monthly income below R800. Such subsidies apply for the purchase of properties costing up to R65 000. (This maximum is likely to be increased in the future).

Two levels of consolidation subsidy are granted to households who reside on a serviced site (the latter financed inter alia by the Independent Development Trust). A subsidy of R7 500 is paid to households with a monthly income of less than R800, while a subsidy of R5 000 is available for households with a monthly income between R801 - R1 500. The consolidation subsidy is for the construction of a dwelling on the serviced site. All consolidation subsidies only apply to officially approved housing projects (as sanctioned by the Provincial Housing Board of KwaZulu-Natal, previously known as the Regional Housing Board of KwaZulu-Natal). The Board is likewise responsible for payment of the standard subsidies. Payment is made to the builder/project developer or the seller of an existing dwelling, and not to the prospective home owner. All subsidies constitute a once-only, non-refundable disbursement by the State. The Board also provides bulk and connector infrastructure grants to developers and local authorities, in order to expedite the delivery of housing.

(v) The estimated composition of the housing stock in Natal/KwaZulu, as at 1990, was as follows (Van Gass, 1993):

Type of housing stock	Percentage in urban areas	Percentage in peri-urban and rural areas
Formal houses	50	4
Formal flats	13	-
Informal orderly	4	1
Informal spontaneous	24	94
Informal backyard	9	1
	100	100

(vi) A useful source of statistics on low cost housing in South Africa is, The housing monitor, published by Settlement Dynamics cc, P O Box 1868, Parklands, 2121. The publication was first issued in November 1989, and is currently in its fourteenth edition (published twice a year). Numerous data are available for each province including the number of housing projects planned, underway or recently completed; the number and types of dwellings or facilities provided at each scheme, and the type and quantity of building materials/fittings used. Other details include financing mechanisms, levels of infrastructure services, and sales figures for low cost housing units. Information is likewise available on developers of schemes. (The original data are maintained in a computerized database). Each issue of the publication also contains a discussion of major housing trends. Example: Lewis, S., 1996. The housing monitor, fourteenth edition, Settlement Dynamics cc, Johannesburg, various pages. A similar information service is provided by Matthew Nell and Associates, P O Box 31713, Braamfontein, 2017. A newsletter entitled, Housing fax, is distributed every two weeks by fax or E-mail. A detailed report on trends in the low income housing sector is issued once a quarter. A further source of statistics on housing is: BMI Building Research Strategy Consulting Unit Ltd, P O Box 784133, Sandton, 2146. The provincial housing boards are important sources of local information on new housing projects.

For further information contact:

- Department of Local Government and National Housing, Private Bag X644, Pretoria, 0001.
- Department of Property Development and Construction Economics, University of Natal, Private Bag X10, Dalbridge, 4014.
- Division of Building Technology, CSIR, P O Box 395, Pretoria, 0001.
- Independent Development Trust, P O Box 16114, Vlaeberg, 8018.
- Institute for Housing of Southern Africa (Natal Branch), P O Box 1479, Pietermaritzburg, 3200.
- National Housing Forum, P O Box 1115, Johannesburg, 2000.
- Provincial Housing Board of KwaZulu-Natal, P O Box 1224, Durban, 4000.
- Urban Sector Network, P O Box 32707, Braamfontein, 2017. (The Network consists of nine affiliated housing organizations including the Built Environment Support Group).

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