A REVISED WATER-DISTRIBUTION POLICY FOR BIODIVERSITY MAINTENANCE IN THE KNP

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1. EXECUTIVE SUMMARY

The 1986 *Masterplan for the Management of the Kruger National Park* stipulates that changing circumstances and new insights make it essential that management practices and policy documents be reviewed at regular intervals.

This document attempts to bring the water distribution policy of the KNP in line with the Mission Statement which states "*To maintain biodiversity in all its natural facets and fluxes and to provide human benefits in keeping with the mission of the South African National Parks in a manner which detracts as little as possible from the wilderness qualities of the Kruger National Park*".

The new water distribution policy for the KNP attempts to simulate the natural distribution of water with the positive consequences it will have on biodiversity, without detracting from the tourist's experience.

A brief overview of the history of artificial water provision in the KNP is given and then the factors that determine water availability in the KNP are examined. The principles involved in the new water distribution programme are examined as well as the policy stipulations for perennial rivers and waterpoints away from perennial rivers.

Suggestions are provided on how to avert perceived problems that the new policy will cause and recommendations are made on the evaluation and closure of certain artificial waterpoints that do not meet certain stated criteria.

The effects of the closure of the nominated artificial waterpoints are examined and its is seen to extend the area of wet season range in the KNP from 17,6% to 32,4% during years with average rainfall. This is thought to be beneficial for especially low density herbivores such as roan antelope.

Lastly, recommendations on the future management of artificial waterpoints in the KNP are given.

It is perceived that this revised water-distribution policy for the KNP will assist in the restoration of intrinsic biodiversity at the landscape level through the simulation of the natural availability of water. It will however be

necessary that a monitoring programme be implemented to assess the consequences of the proposed water distribution policy.

2. INTRODUCTION

Natural water in the KNP occurs as flowing perennial rivers, pools in seasonal rivers, and springs and water in pans. The pans and springs can be close to or removed from rivers. Perennial rivers are influenced mostly by rain falling outside KNP boundaries and are impacted by human developments, forestry, agriculture and dams outside the KNP boundaries that affect flow. Rain that falls over KNP and immediately adjacent areas influences the pans and pools in seasonal rivers that originate within or close to the KNP boundaries.

The spatial and temporal distribution of water is the major factor determining population dynamics and maintaining viable populations of most (if not all) the larger mammal populations of the KNP, in addition to the multitudes of lesser vertebrates and invertebrates dependent on water to survive and/or complete their life cycles.

Waterpoints are also beneficial through providing focal points for tourists, contributing to the attractiveness of a park, and thereby enhancing the economic viability of protected areas. Nevertheless, in certain circumstances they may compromise basic conservation aims: maintenance of biodiversity, sustainability of resources and maintenance of ecosystem processes.

The KNP Mission Statement has as one theme "*To maintain biodiversity in all its natural facets and fluxes* .... ", and this implies allowing natural processes and functions to fluctuate according to rainfall cycles, and also to create a patchwork mosaic of water availability. The fact that there are areas close to and far from surface water contribute to landscape heterogeneity which is seen to be desirable in modern ecological management terms.

3. HISTORY OF WATER-PROVISION IN THE KNP

When the Sabie Game Reserve was proclaimed in 1898 and the Shingwedzi Game Reserve in 1903, there were no artificial water impoundments in what is now the Kruger National Park. Game numbers were low as a result of persistent hunting and the great rinderpest epidemic of 1896. The vegetation structure was also different from the present with for instance open grassy plains in the Pretoriuskop area and extensive stands of tall mlala palm trees (*Hyphene natalensis*) on the northern basalt plains, certain differences which we interpret as being the result of human influence at that time.

Ranger outposts were established near sources of permanent water and in 1922 Stevenson-Hamilton noticed that the Sabie River was being seriously polluted by small gold mines on its upper reaches. In the early 1930s after the Skukuza Rest Camp was opened to the public, visitors lodged complaints about the condition of the water. Boreholes had to supply Skukuza with water and the pollution of the river continued until the end of the Second World War. The Sabie River subsequently became one of the cleanest and biologically richest rivers in the Lowveld.

On the 31 st May 1926 the National Parks Act was directed through Parliament of the then Union of South Africa and the Kruger National Park came into being.

As early as 1927 the possibility of boreholes to provide water for game during droughts was mentioned at a Board Meeting. Stevenson-Hamilton however informed the Board of Trustees that boreholes were not yet required. This matter was raised again in 1929 and although boreholes were deemed to be not practical, it was decided that water must be preserved in the KNP and the Warden was instructed to make a survey of suitable dam sites in spruits (dry watercourses).

Reasons given for the stabilization of the water supply included making the more arid areas more accessible to game in order to spread the animals more evenly over the whole of the Kruger Park, and to prevent emigration of animals out of the KNP which was still unfenced.

Brynard (1969) as quoted by Pienaar (1985) identified five phases in the history of what became the artificial water-for-game programme in the KNP.

The **first phase (1929 - 1946)** of the water provision programme started in 1929 with the Board's decision to provide artificial water in the KNP. During 1931 the well-known Ntomene waterholes along the old Delagoa Bay transport road finally dried up. This caused great concern and it was decided to build the first concrete dam in the KNP at that locality. This dam was completed early in 1932.

In the meantime the Warden appealed to the Board of Trustees for funds for a series of boreholes at places where in the immediate past there had been water available to game. Eventually the Board raised more than ,2 500 for the borehole programme and the Government donated two boreholes. The drilling programme commenced in October 1933 with the first borehole being sunk for Pretoriuskop Rest Camp. A number of successful holes were drilled at places such as Komapiti, Randspruit, Gomondwane, Skukuza koppies, Hlambamadvube and Manzi-mahle. During 1934 and 1935 boreholes were sunk at Marheya, Gudzane, Bangu, Shivulani, Ngwenyene and Malopene.

Small dams such as Kumane, Mazithi, Mooiplaas Vlei and Folly Dam were built and on the on the northern Lebombo plains, wells were dug and windmills erected at Stangene, Babalala, Nwarihlangari South, Nkukumbene North, Nwashitsumbe North, Dzombyane, Mashikiri, Masandje, Nkovakulu and Klopperfontein. During 1944 construction on the Orpen Dam near Tshokwane was started with funds donated by Mrs Eileen Orpen.

The **second phase (1946 - 1952)** started in April 1946 Colonel J.A.B. Sandenbergh succeeded Colonel Stevenson-Hamilton as Warden of the KNP and he took up the challenge of the water supply programme with great enthusiasm. A sudden revival in the water supply programme took place, and Board funds, as well as money collected by the public were used to improve the situation, especially by means of boreholes.

During the **third phase (1953 - 1960)**, before the fencing-off of the western boundary, relatively little was done, except for a few dams that were built. The idea was voiced by some that there was no further need for water for game.

The **fourth phase (1960 - 1969)** saw a revival of the water provisioning programme and during this stage about R269 000 was spent on water for game. This was more money than what was spent on water for game than during the preceding 31 years. The erection of the western boundary fence in 1961 disrupted the migrarion of game herds and a number of boreholes were sunk to provide water for the milling mass of thirsty game. The drilling programme was also intensified to lessen the effects of the prolonged drought by providing water at or near sites where natural waters were progressively drying up (Pienaar, 1985).

The **fifth phase (1969 - 1990)** entailed the strengthening of the water position in the major rivers and their large tributaries. The Letaba River had recently turned from a perennial river into a seasonal river as a result of damming and agricultural practices upstream of the KNP. The Engelhard Dam was completed towards the end of 1970 and was fitted with a fish ladder. During the wet cycle of 1971 - 1981 the water stabilising programme in the major rivers continued without interruption in anticipation of the next dry cycle.

During 1971 earth dams were built in the Newu, Stolznek and Mpondo spruits and the Shireni concrete dam was built in the Mphongolo river.

The deteriorating state of the perennial rivers caused great concern and a series of weirs (Black Heron, Mingerhout and Shimuwini) were constructed in the Letaba River to stabilize this once perennial river. Dams were also built in the larger seasonal rivers to compensate for large permanent waterholes that recently started to dry up. The Shireni Dam in the Mpongolo River was built to provide water when the Mavatsane, Dzundula and Mavatsane pools dry up (Pienaar 1985). The dams in the tributaries of perennial rivers was also seen as refugia for certain aquatic species when perennial rivers are threatened with desiccation, pollution and excessive silt loads (Pienaar 1978).

In 1976 the eastern boundary of the KNP was fenced off with elephant-proof fencing as a result of deteriorating international relations and political turmoil in Mozambique. The KNP was now almost fenced in completely. The game within the park was now completely dependant for survival on local natural resources including those which are man made. Mass migration to escape natural catastrophes such as droughts and extensive veld fires was now impossible (Pienaar 1985).

In 1987 a concrete dam was completed in the Sabie River at Lower Sabie rest camp with a gauging weir 5 km downstream. At this stage the Sabie River was biologically the richest river in the KNP and there was a great and real concern that it would stop flowing and that it would lose that aquatic life dependant on well-aerated flowing water. For this reason a water reticulation system was erected in 1990 to pump water from the weir back to the dam to ensure flowing water in a section of the Sabie River should flow cease. Fortunately it has not yet been necessary to use this system.

In 1988 the Piet Grobler concrete dam was competed in the Timbavati River at Mbangari where there used to be a large and deep hippo pool. This was the last large dam to be built in the KNP and it was also fitted with a fish ladder.

During 1988 the first solar-energy pumps were installed at boreholes. These pumps had the advantage that they are aesthetically more appealing than windmills, they are more efficient than windmills and they are a alternative to large dams as they can provide water even when the wind is not blowing. They are unfortunately more expensive and may thus not replace all the windmills.

The reservoir and trough programme to stabilize windmills was completed in 1990. A number of free-form troughs were also constructed at windmills next to tourist roads to give a more natural appearance to the troughs.

Pienaar (1985) foresaw a sixth phase which would entail consolidation and elimination of the mistakes made in the past. Greater knowledge about the long-term and short-term rainfall cycles and its effect on the animal populations, the removal of the western boundary fence and recent experience of herbivore population dynamics and interactions will guide this phase. It will probably imply that certain boreholes (for example those in the traditional summer grazing areas) will be removed, and that some dams which were built in the past will serve no further purpose and will be drained or even removed, if necessary (Pienaar, 1985).

We saw the beginning of this phase in 1994 when 12 boreholes were closed and one earth dam (Stangene Dam) was drained on the basalt plains north of Shingwedzi. This was motivated by a drastic decline of low density herbivores (roan antelope, sable antelope and tsessebe) in this area. In contrast, a rapid increase in zebra and lion numbers were experienced in the same area and an increase in competition and predation coupled with a deteriorating veld condition were thought to be the main causes of the roan decline. The artificial waterpoints were closed in an effort to push zebra and lion off the plains and to provide more tall grass refuges for the roan. This seems to have had the desired effect as zebra numbers on the plains declined and the roan numbers stabilized.

Whichever way phase six develops, Mr Brynard, a past Chief Director of the NPB can be cited: "Nobody should be allowed to look down with scorn upon the achievements of the past. Every borehole drilled, every windmill erected, every wheelbarrow of concrete, and every bucketful of soil were accompanied by hard labour, more often than not, under difficult circumstances, many hours of planning and often meagre funds that were needed in many places at the same time. The Kruger National Park and its animals can look back gratefully to what had been done for them" (Pienaar, 1985). Although all this was done in good faith and through hard work, the time has come to evaluate each artificial waterpoint critically and to close the ones located in undesirable localities, in an effort to embrace landscape heterogeneity.

4. FACTORS DETERMINING WATER AVAILABILITY IN THE KNP

a) Oscillations in rainfall

Medium term climatic fluctuations, with approximately 8 - 10 years of generally above-average rainfall and similar spells of generally below average rainfall, were acknowledged by Stevenson-Hamilton (1938) and confirmed with more substantial data by Tyson and Dyer (1975) and Gertenbach (1980). Long term oscillations, in the order of 80 - 100 years, have also recently been suggested by Pienaar (1985).

During the dry spells the KNP hade always had very limited surface water supplies other than the perennial rivers and isolated springs and waterholes in seasonal watercourses. Before Stevenson-Hamilton became aware of the rainfall cycles he was firmly of the opinion that the Lowveld was being subjected to a gradual progressive desiccation, and even desertification (see Era's 1898 - 1926 and 1926 - 1946). This point of view is supported by Pienaar (1986) on the basis of an analysis and interpretation of historical data and seems to be supported by recent climatological analysis (Mason, 1996) and global climate change scenarios.

In the latter years of his term of office Stevenson-Hamilton (1938, 1944) fully accepted short and medium term climatic cycles, and the associated responses of the animal populations and vegetation. It is important to note, however, that prior to the fencing of the KNP the animal populations had the advantage to migrate/disperse to water resources beyond the limits of the KNP - a situation that no longer exists, but whose previous scale and extent is not well understood exept for the wildebeest movements over the western boundary of the KNP before it was fenced off (Whyte, 1985).

b) The fencing of the KNP

With the fencing of especially the western boundary of the KNP in the early 1960's, access to large tracts of the favoured summer and winter habitats of migratory animal populations, especially wildebeest and zebra, was cut off for animals in the KNP. The winter ranges included perennial water resources such as the Sand River. The exclusion of such water resources prompted the move to provide alternative water resources along the western boundary area - in fact, such a contingency was foreseen even before the fence was erected. The provision of water alone, without the substitution of the habitats that were excluded, was not successful in saving the western boundary migratory wildebeest and zebra populations (Whyte, 1985).

The eastern boundary fence was finally completed during the high rainfall phase of the climatic cycle during the 1970's. This fence effectively cut off the migration/dispersion routes of species such as eland, elephant and others to and from Mozambique, and its effect could not be ignored in the formulation of management strategies, such as the provision of artificial water supplies.

c) Abuse of perennial rivers

Since the early 1920's the perennial rivers have sporadically been subjected to a series of incidents of pollution and, particularly from the mid-1940's, to increased silting and deteriorating water quality. These phenomena were intimately related to industrial and agricultural expansion, as well as to the fast growing rural populations in the Lowveld and adjoining areas. While the quality of the water in the rivers was the first to be affected, heavy silting and extraction also soon led to a progressive decrease in the quantity of water.

This led to a cessation of water flow in rivers such as the Letaba and Luvuvhu, recorded for the first time during the late 1940's. In addition to these rivers, the water flow in the Crocodile and Sand rivers also stopped during the protracted drought of the 1960's. The drought of 1992 accentuated the seriousness of the situation when both the Luvuvhu and Letaba rivers stopped flowing for longer than 10 months. The base flow of the Sabie, Olifants and Crocodile rivers were only maintained through negotiations with neighbours in catchment areas, resulting in restrictions on abstraction (often voluntary) on releases from dams.

5. OTHER CONSIDERATIONS FOR THE PROVISION OF ADDITIONAL WATER RESOURCES

Other than water availability from currently recognized water sourses, a number of motivations through the years have prompted the provision of additional water supplies. Importantly, these reflected the desire to obtain a more even utilization of the available grazing. Concomitantly, this was also intended to increase the numbers of animals. An additional motivation was to provide water as an attraction to animals for the benefit of tourists. An increase in the numbers of highly gregarious large mammals, specifically buffalo and elephant, provided the incentive for the construction of large earthen and concrete dams. Dams of this nature were seen to fulfil a triple purpose: to relieve the perennial rivers of excessive grazing pressure during the dry (winter) season, to avert competition between species by providing sufficient opportunity for spatial separation on long water frontages, and to provide additional refuges for endangered forms of aquatic life away from the rapidly drying perennial rivers.

Since none of these latter considerations are ecologically sound and therefore not in line with present KNP philosophies which strive to simulate natural fluxes, they no longer represent adequate motivation for the provision of artificial water (except for the possible justification as a refuge away from the rapidly drying perennial rivers).

6. THE ECOLOGICAL ROLE OF WATER

In an ecosystem context water has many vital functions: providing drinking water for water-dependent species, providing a habitat for aquatic biota, it determines plant growth, nutrient cycling, soil movement, etc. In an indirect sense, water-free areas provide important refuges for certain plant species and act as dispersal areas during the wet season.

In terms of water-dependent animal species, water plays an all-important role in determining distribution and density patterns. The ecological role of water is further enhanced by its availability, distribution and the form in which it is available. The availability of surface water is directly related to rainfall, soil propertias and land form. Availability could, however, also be affected by factors influencing run-off, such as the degree of afforestation of catchment areas, the condition of the field layer of the vegetation, the depth of the water table, etc. It nevertheless remains a fundamental consideration that the availability of surface water is an environmental variable in harmony with the other components of the ecosystem, as dictated by rainfall. Abundant water supplies reflect high rainfall and consequently tend to produce a lush vegetation and a generally wider distribution of the animal populations. Similarly, a general lack of water is a result of low rainfall, with a concurrent lower primary production, poorer grazing and browsing conditions and more contracted distribution patterns amongst the animal populations. Water in its natural state is, therefore, an essential element in retaining natural diversity.

Water distribution is obviously closely related to, but not entirely synonymous with availability. After rains water might be widely distributed but only be available for a short period or a small spring might only be able to provide a few animals with water. The distribution of water dictates which areas (habitats) are available to animals. As the relative densities of animal populations reflect the suitability of habitats, it is obvious that the distribution of natural water supplies also plays an important role in maintaining the relative abundances of the populations involved. Such relationships are important in maintaining ecological stability and resilience. Thus water distribution, in relation with other environmental factors, plays an essential role.

In the KNP ecosystem water is naturally available in the form of flowing perennial rivers (the nature of these rivers varies from those with broad sand beds with gently sloping banks and dense and/or sparse riparian vegetation to steep banks with dense and/or open vegetation and rocky gorges, with several gradations from one extreme to the other even along the same river), isolated pools of varying permanence in seasonal watercourses, isolated springs, and pans of varying sizes. Pans are normally small and seasonal, with the larger pans confined to particular landscape types. Water in the largest pans lasts no longer than two seasons without replenishment. In the natural state there are no wide expanses of open perennial water in the KNP. In accordance with any other compositional and structural features of habitats, the form and quantity in which water is available plays an important part in determining the suitability of habitats for particular species. As such, it also contributes significantly towards the maintenance of structural and species diversity. The maintenance of such diversity is a fundamental consideration in the managing the KNP.

The second important function of water is the provision of habitats for aquatic and amphibious life. In this respect natural water resources represent aquatic ecosystems, which are as important in terms of conservation priorities as the terrestrial ecosystems. In addition to larger mammals such as hippo and otters, numerous small mammals, a rich and varied avifauna, reptiles and amphibians, water ecosystems also host flora and fauna unique to them. The conservation of the qualities, interdependencies, and the structural and species diversity of such ecosystems represent an integral part in the conservation strategy of the KNP.

7. PROPOSED NEW WATER POLICY

7.1. Principles involved in the water distribution programme

Only in the case where the water provision programme was instituted as a contingency measure to counter the disruptions caused by the erection of the boundary fences, or in the case of weirs in the perennial rivers where the quality and quantity of the water had deteriorated through unnatural interferences, such action may be based on the principle of the preservation of diversity. In these cases certain reservations may, however, be raised. Where water provision was intended to counter the effects of the fencing of the boundaries and the exclusion of traditional water resources, the principle would hold good for the more sedentary species which occupied habitats within the KNP and were excluded from the water resources. However, in the case of species which were dependent on habitats beyond the KNP boundaries, in addition to the water resources, the provision of only one of a number of habitat features could hardly be expected to provide a suitable solution. This has been sufficiently illustrated with the dramatic decline in the migratory wildebeest and zebra populations along the western boundary of the Central District. It is reasonable to accept that, to a large extent, the declines were in relation to the loss of habitat beyond the KNP boundaries (Whyte, 1985).

However, the situation should also be seen in its broader perspectives. It has been recorded (Stevenson-Hamilton, 1913) that during times of severe drought all the known water resources along the western boundary between the Olifants and Sabie rivers dried up. Under these circumstances the animal populations either had to disperse to areas where water was still available within the KNP or to the more perennial resources in the foothills of the Drakensberg.

In the past the construction of weirs in the perennial rivers was merely considered a "holding action" to provide refuges for the aquatic life and hippo populations as relief from the depletion of the natural flow of water in the rivers. There is, however, evidence from other similar projects that such artificial structures could have a detrimental effect on various aspects of the aquatic ecosystems. Experience gained from the building of the dams in the Letaba River showed that such dams silted up within 15 years and that they were not capable of maintaining perennial flow in the river for which reason they had been built in the first place. Furthermore, they represent large manmade structures which are often aesthetically unacceptable. The question therefore, is how to resolve the problem with the least possible effect on the river ecosystems. The ultimate solution obviously lies in a regional plan of action in which sufficient provision may be made for all interested parties dependent on the perennial rivers, and which would ensure a perennial water flow of prescribed quantity and quality through the KNP. Progress are being made with the establishing of river-catchment management plans.

Such broad-scope projects commenced with the establishment of the KNP Rivers Research Programme in 1987. The extensiveness of the Programme and the resulting public realization of the magnitude of the problems, led to the establishment of several committees, working groups, etc. in the catchments of the KNP rivers.

It is accepted that there is a national and international pressure on industries and farmers to curb pollution drastically and to assure that water quality is acceptable for downstream users. The chances of chronic industrial pollution close to the KNP are therefore hopefully becoming slimmer. It is furthermore accepted that any catastrophic pollution event would usually only affect one river and that species which are dependent on perennial flow would survive in some of the other perennial or seasonal flowing rivers. Therefore, due to the highly changing and negative effect of dams in rivers and their smaller tributaries, their apparent disability to present habitat for most of the aquatic organisms, their disruptive effect on terrestrial animal and plant populations, as well as their impact on the aesthetics of rivers, approval for construction of more dams in the KNP is unlikely to be procured.

The principles related to the provision of artificial water can be summarized as follows:

i) It is accepted that the availability of surface water resources other than perennial rivers in the KNP are primarily dependent on the annual, medium and long term rainfall cycles.

ii) Due to the fluctuating nature and intensity of rainfall, both in terms of medium and longer term cycles, it is also accepted that the surface water resources will fluctuate accordingly and that such fluctuations have played a decisive role in moulding the intricacies of the Lowveld ecosystems.

iii) It is also accepted that the KNP has been restricted in its entirely natural development by spatial and other unnatural limitations (boundary fences etc.) although the extent of this has not been accurately assessed.

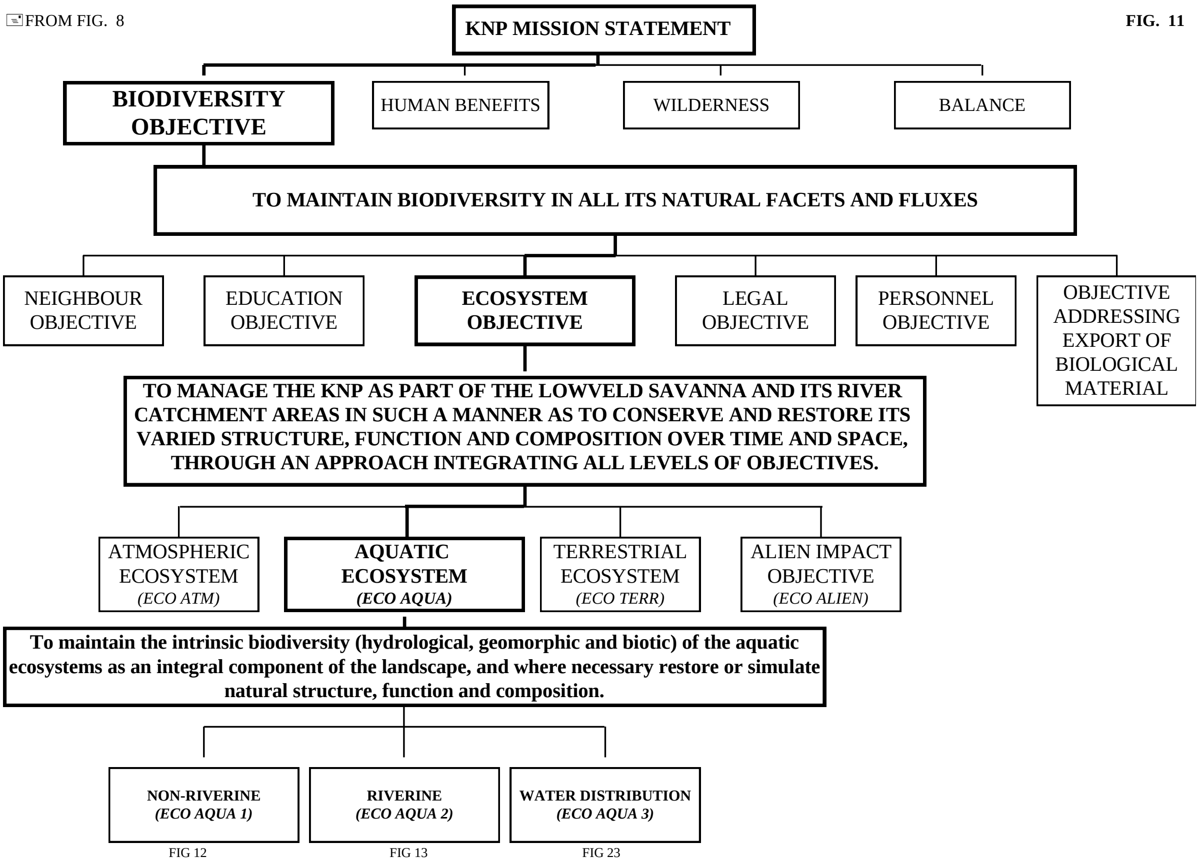
iv) As far as flow and quality of water in the perennial rivers flowing through the KNP are concerned, it is accepted that the KNP rivers are largely dependant on what happens in the catchments outside the KNP and that very few managerial measures inside the KNP can be taken to effectively conserve these systems. Constant and active contact with water users and managers outside the KNP should therefore be sought by the KNP to negotiate the maintenance of flow and quality, until appropriate legislative measures have been implemented.

7.2. Objectives hierarchy as identified in recent policy review process

The three pages of the Objectives Hierarchy for the Management of the KNP presented hereafter (Figures 11, 23 and 24) were taken from Volume VII and illustrate the objectives and goals relating to water distribution in the KNP.

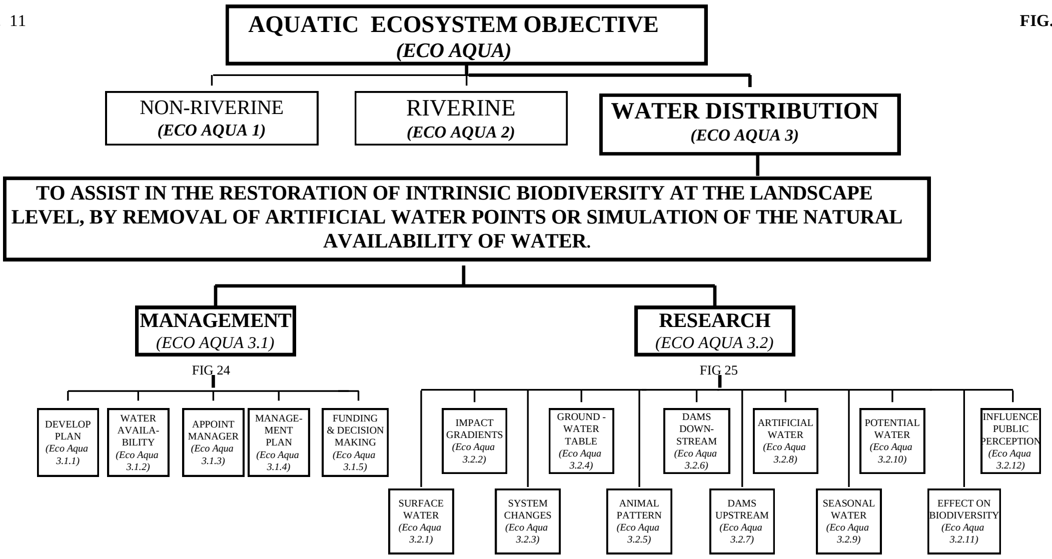
FROM FIG. 8

FIG. 11



FROM FIG. 11

FIG. 23



FROM FIG. 23

FIG. 24

AQUATIC ECOSYSTEM OBJECTIVE
(ECO AQUA)

NON-RIVERINE
(ECO AQUA 1)

RIVERINE
(ECO AQUA 2)

WATER DISTRIBUTION
(ECO AQUA 3)

TO ASSIST IN THE RESTORATION OF INTRINSIC BIODIVERSITY AT THE LANDSCAPE LEVEL, BY REMOVAL OF ARTIFICIAL WATER POINTS OR SIMULATION OF THE NATURAL AVAILABILITY OF WATER.

MANAGEMENT
(ECO AQUA 3.1)

RESEARCH
(ECO AQUA 3.2)

DEVELOP PLAN *(Eco Aqua 3.1.1)*
Develop and implement a plan for the phased removal of artificial waterholes , condonation of certain artificial waterholes, and the simulation of natural water distribution.

WATER AVAILABILITY *(Eco Aqua 3.1.2)*
Review the current water-availability (especially artificial sources) during the coming wet season and annually thereafter, producing a report with recommendations.

APPOINT MANAGER *(Eco Aqua 3.1.3)*
Appoint a manager: Water Resources.

MANAGEMENT PLAN *(Eco Aqua 3.1.4)*
Draw up a management plan for the operation of existing ,or removal of artificial water points.

FUNDING & DECISION MAKING *(Eco Aqua 3.1.5)*
Develop guidelines for funding and decision-making regarding repair, neutralisation or removal of dams.

7.3. Water distribution policy

Based on the ecological role of water and the unnatural influences which have been imposed on the KNP, the water provision policy may be divided into two main categories, i.e. water provision away from the perennial rivers, and stabilization of the perennial rivers.

7.3.1 Water resources away from perennial rivers.

i) In consideration of the above-mentioned factors the artificial provision of water is accepted as justified, provided:

(a) It is in accordance with natural ecosystem principles.

(b) Full control may be exerted over the resource.

ii) To achieve these objectives the following considerations are of relevance :

(a) Water may only be provided to augment existing natural resources.

(b) Water resources should not be created to overrule the ecological effects of natural climatic and environmental fluctuations.

(c) Provision of artificial water supplies should not be designed to alter (disrupt) the natural distribution and relative density patterns of animal populations or aquatic systems, including seasonal differences.

iii) Due to the need for control over artificial water resources, the implementation of the water policy could best be achieved by a system of boreholes.

iv) These artificial water holes should be properly managed and closed down when they are not necessary (i.e. when adequate veld water is available) to give the veld a resting period and to allow for a more natural pasture rotation grazing pattern.

v) As a contingency measure, but only under particularly severe conditions (e.g. protracted drought periods), and only where the severity of such conditions may be intensified through the constraints imposed by the fencing of the KNP, a system of supplementary boreholes may be provided in established dry season (or winter) concentration areas.

vi) Catchment dams in seasonal watercourses are normally no longer justified in providing additional water resources during periods of drought and for conserving water for underground water replenishment due to the following reasons:

(a) Wide expanses of water are alien to the KNP ecosystem.

(b) Full control over the water resource is difficult due to the practical problems related to the provision of sluices.

(c) Dams in small tributaries usually flood the riparian vegetation and many large and old trees are drowned or have to be removed.

(d) Several of the older existing dams have not been able to retain water during the drought periods they had been intended for.

(e) Established ecological patterns, both terrestrial and aquatic, are usually disrupted by such dams.

(f) Dams are artificial, man-made structures which impact negatively on wilderness qualities and "sense of place".

vii) Dams in watercourses of which the entire catchment are situated within the KNP are particularly unacceptable since they were found to be unable to serve as reservoirs for most of the aquatic biota of the perennial rivers.

viii) Dams and windmills which have already been constructed in the KNP and which do not comply to the above principles, should be identified and systematically closed down and the areas affected should be rehabilitated.

7.3.2 The perennial rivers

i) The gradual desiccation of the perennial rivers of the KNP, as evidenced by a reduced flow of water, higher silt levels and deteriorating water quality inspired managerial measures to improve the rivers as a source of drinking water for the preservation of the aquatic ecosystems. The situation with regard to the rivers flowing through the KNP looks better now than it has for the past 40 years, inasmuch as there is far more societal commitment to river health, albeit in the face of even greater environmental pressure on the rivers in modern times. These changes are related mainly to:

a. Changes in the new Water Bill and general policy with regard to rivers.

b. A much increased awareness about the plight of rivers.

c. An increased status of conservation areas and issues relative to other sectors such as irrigation farming and forestry, also manifesting in the new Water Bill by giving higher priority to basic human needs, maintenance of aquatic systems and international obligations than other user sectors.

d. Weight given to river conservation by prestigious programmes such as Kruger National Park Rivers Research Program (KNPRRP), National Aquatic Ecosystem Biomonitoring Program (NAEBP), Working for Water Program, Instream Flow Requirements (IFR) process, Integrated Environmental Management (IEM) principles, etc.

e. The increased thrust to implement Integrated Catchment Management (ICM) through Catchment Management Agencies (CMA=s - also provided for in the new bill).

ii) The ultimate and ideal solution to the problems related to the rivers is to restore the flow of water from outside the KNP and its quality in all the perennial rivers. The only way in which this could be achieved is through a co-operative programme of water and environmental conservation entailing the entire catchment area and in which all interested parties dependent upon and/or exerting an influence on the rivers are compelled by appropriate legislation to participate in the programme. The National Parks Board commits itself to continued efforts and active participation towards achieving such an objective.

iii) Legislation in the form of the new water act will in the near future provide for a minimum flow of water in each river, based on the maintenance of the aquatic system. Actual water quantities needed by each river have been determined by the KNPRRP and IFR studies, but still need to be refined.

iv) The provision of weirs within the boundaries of the KNP to serve as silt catchments and habitats for the hippo populations and other aquatic life was found to be ineffective in maintaining perennial flow for other aquatic organisms, due to the fact that they cannot be built to hold enough water. They were also found to have a significant detrimental effect on various aspects of the river ecosystems and completely change the character of the river and surrounding area. Therefore, they should no longer be considered as an options for the conservation of the river systems.

v) Provision for the maintenance of water flow to sustain the aquatic life should as far as possible be made in the form of better management and pricing of available water resources, water conservation campaigns and programmes and only in extreme shortages by large dams in the upper catchment areas of the perennial rivers.

vii) As far as existing weirs in perennial rivers in the KNP are concerned the following procedures should be followed:

(a) Determine whether it would be possible and feasible to remove the weir without causing major impacts to the environment e.g. the release of large quantities of silt to lower sections of the river.

(b) If not, provide a fish ladder which would facilitate natural fish migrations. The long term goal however should still be to seek effective ways to revert to a more natural situation and to do away with unnatural or man-made structures.

8. PROBLEMS IN IMPLEMENTING A NEW WATER POLICY

In the event of certain artificial water-holes which are popular tourist viewpoints being closed down one could expect tourists to react negatively to such an action. This will have to be addressed by a campaign aimed at informing the public of the ecological reasons for the closure of certain waterpoints.

Game distribution will be affected by the proposed waterpoint closure. It is therefore suggested that the waterpoints be closed in the wet season when abundant water is available. As the natural water starts drying up at the and of the wet season the game will gradually adjust their distribution to conform with the remaining artificial and natural waterpoints. An analysis of longterm rainfall data indicates that the KNP might presently be entering a wet rainfall cycle and it is probably a good time to start the closure of identified artificial waterpoints. Most herbivore populations declined during the past dry cycle and it will be advantageous to close the identified waterpoints before their numbers have built up again.

9. RECOMMENDATIONS AS TO THE CLOSURE OF CERTAIN IDENTIFIED ARTIFICIAL WATERPOINTS

All existing artificial waterpoints and the ones that are still in the planning process need to be evaluated by the following criteria (Table 1). The artificial waterpoints that do not qualify need to be closed down. It is suggested that the closure be done in three phases and that the process preferably be completed within the next 10 years.

During the **first** phase all artificial waterpoints in localities where there would not normally be water should be closed after the first good summer rains when veld water is abundant. All artificial waterpoints in the pristine hiking wilderness should also be closed at this stage. Boreholes next to tourist roads will not be closed during this phase.

The **second** phase should be implemented at least two rainfall seasons after phase 1. During this phase all artificial waterpoints along drainage lines which originate inside the KNP need to be critically evaluated. During this phase the need for additional boreholes to compensate for the loss of natural water need to be identified.

During phase **three** all dams in drainage lines that originate inside the KNP need to be critically evaluated. If a dam is deemed to have a negative effect on the ecology of the KNP it should be drained and the area rehabilitated. This will necessarily be a very expensive exercise and will need to be approached carefully.

10. PROPOSED CRITERIA FOR THE EVALUATION OF ARTIFICIAL WATERPOINTS

1. Ascertain if water occured in that area naturally and what was the permanence of such natural water, in both wet and dry cycles.

2. Determine if the artificial waterpoint compensate for natural water that used to be available in the area but are now through some unnatural or manmade cause is no longer available.

3. All artificial waterpoints must be closed down in the pristine wilderness zones except if criteria 2 applies.

4. In some cases the permanent existence of an artificial waterpoint could be justified on the basis of special ecological reasons such as if such a waterpoint is an important watersource for a rare species.

5. One must look very critically at artificial water provision in or next to drainage lines that have their origin inside the KNP as outside human impacts should have a small effect on natural water distribution in these areas.

6. Avoid the placement of artificial water in "traditional" summer grazing areas.

7. Certain artificial waterpoints which do not meet the above criteria but which are favourite tourist viewpoints and fall within the motorized zone of the KNP should be condoned if they do not have major negative ecological implications.

Table 1: List of boreholes in the KNP to be closed during phase 1 and those to remain open

Ranger section and Locality	**Stay open** **Yes = 🔔** **No = X**	**Criteria appraisal**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Pafuri								
Bvumanyundu	X	x	x				x	
Gwalali	X		x					
Klopperfontein	?	x				x		
Koorsboom (SP)	X	x	x		x			
Kremetart	X					x	x	x
Lala Palm	🔔	x	x		x			
Mashikiri	?			x		x	x	x
Mazanje	X			x			x	x
Nkovakulu (SP)	?			x		x	x	x
Paradys (SP)	🔔	x	x		x			
Njalaland	?							
Punda Maria								
Coetzer (Punda fontein) (SP)	🔔	x				x		x
De Jager	X	x				x	x	
Dothole	🔔		x			x		
Elandskuil	🔔 ?						x	x
Magamba (Dzundwini spring)	🔔	x				x		x
Mahembane (SP)	X					x	x	
Mananganganga	?					x	x	
Mandadzidzi (SP)	?						x	x
Marithenga (SP)	?					x	x	
Ntsumanini	X					x	x	
Witsand	?					x	x	
Botha	X							
Vlakteplaas								
Babalala	🔔	x				x		x
BG Kamp	X				x			
Bittergal	X	x				x	x	

Boyela (SP)	?	x				x		x
Boyela Noord	X	x				x	x	
Brandwag (SP)	X	x			x	x	x	
Hlamalala Noord	X	x			x	x	x	
Hlamalala Suid	X	x				x	x	
M⊥rewag	X	x			x	x	x	
Nkulumbeni Central (SP)	?	x				x		
Nwarihlagari North	X	x			x	x	x	
N'washitshumbe (SP)	X	x				x	x	
N'washitshumbe North	X	x			x	x	x	
Papanyne (SP)	X	x			x	x	x	
Shanatseni	X	x				x	x	
Shingomeni (SP)	?	x				x	x	
Shisha-Wes	?	x				x		
Stagnene (WG Shisha)	?	x				x		
Steenbokpan	X	x			x	x	x	
Vlakteplaas	X	x			x	x	x	
Shangoni								
Bububu (SP)	X	x	?	x		?	x	
Dili (SP)	🔔	x	?	x				
Figtree (SP)	?	x		x		x	x	
Grootgeluk	🔔	x	x	x				
Hlanguphalala	🔔	x	x	x	x			
Mafunyane (SP)	?	x	?	x		?	x	
Nalatsi	X	x		x	x	x	x	
Nkayeni	X	x			x		x	
Phungwane Oos	🔔	x	x	x				
Swartpiek	🔔	x	x	x				
Timatorha	X	x		x	x	x	x	
Tussenin	?	x	x	x			x	
Shimuweni (SP)	?	x		x		x		x
Woodlands								
Awie-se-dam (SP)	X	x	?	x		?	x	
Bakoor	X	x		x		x	x	
Bateleur-ruskamp	🔔	x		?				x

Boomplaas	🔔	x	x	x				
Buig of Bars	X			x		x		x
Dzombo-wes (SP)	?					x	x	x
Dzundzula (SP)	🔔	x	x	x				
Joao (SP)	🔔	x	x	x				x
Mbomeni	🔔	x	x	x				
Mopaniedraai (SP)	X			x		x	x	
Nkokodzi	?					x	x	x
Nwamba	?					x	x	x
Phonda (SP)	?	x	?	x				
Qivi-ra-Mashangana	?	x	?	x				
Red Rocks (SP)	🔔	x	x	x				x
Sandpiper (SP)	🔔	x	x	x				
Tomlinson (SP)	🔔	x	x	x				
Shiphandze (SP)	?	x	?	x				
Wag-'n-bietjie	X	x		x		x	x	
Shingwedzi								
Gorra	🔔	x	x	x				
Lamont	🔔	🔔	🔔					x
Mashagadzi	?					x		x
Mpenza (SP)	X			x		x	x	
Ndlopfini	X			x		x	x	
Nkulumbeni Suid	?	?				x	?	x
Nwamayiwani	X			x		x	?	
Nwarihlangari	🔔					x	x	x
Tsumani (SP)	X			x		x		
Vergesig	?			x		x	x	
Mooiplaas								
Bovlei	X					x	x	
Bowkerkop	🔔	x				x	x	x
Capricorn	X					x	x	
Dzombo-oos	X			x		x	x	
Dzombyana	X			x		x	x	
Eendrag	🔔	x				x	x	x
Grysbok	🔔	x				x	x	x

Hartbeesbult (SP)	X					x	x	
Klein-Nshawu (SP)	X			x		x		x
Mahlati (fontein)	X	x		x		x		
Manyeleti	X			x		x	x	
Mooiplaas	🔔					x		x
Nwatimhofu	X			x		x	x	
Nshawu No2	X			x		x		x
Nshawu No3 (SP)	X			x		x		x
Nshawu No5	X			x		x		x
Shidakeni	X			x		x	x	
Tihongonyeni (SP)	?					x	x	x
Voetpad	X			x		x		x
Mahlangeni								
Baanbreker	X					x		x
Boulders-ruskamp	?					x	x	x
BromvoNl	?			x		x		
Dwaalspoor	?					x	x	new zoning x
Frazersrus (SP)	X					x	x	x
Ietermag⊥	?	x		x		x		
Joubert-se-graf	X			x		x	x	
Mahubyeni (SP) (pan)	X	x		x		x	x	
Matiyotshwuka (SP)	?			x		x	x	
Nietverdiend	X					x	x	new zoning x
Nsihana	X			x		x	x	
Onverwag (SP)	X					x	x	new zoning x
Phambi	X			x		x	x	
Stamp-en-stoot	X			?		x	x	new zoning x
Tsale (SP)	?					x	x	x
Tshombyeni-noord (SP)	X			x	?	x	x	
Tshombyeni-suid	?			x	?	x	x	
Welgelegen	?					x	x	x
Shipikani (SP)	X			x		x	x	
Phalaborwa								
Malopeni-noord	X			x		x	x	
Machangani	X					x	x	new zoning x

Masorini	?					x	x	x
Ngwenyeni (SP)	?			x		x	x	x
Oorgenoeg (SP)	X					x	x	
Vudogwa (SP)	?					x	x	x
Letaba								
Bullfrog (already closed)	X			x		x	x	
Erfplaas	X			x		x	x	x
Jumbo	X					x	x	x
Ledeboer	X	x		x		x	x	x
Lokval	X					x	x	x
Macetse (SP)	X	x				x	x	x
Makhadzi (already closed)	X			x		x	x	
Malopenyana	?	?				x	?	
Marhumbeni	X					x	x	x
Middelvlei (SP)	?					x	x	x
Mulalani	X					x	x	?
Nandzana	?					x	x	x
Ngobeni (SP) (WG)	?	x				x	x	x
Nhlanganini	X	?				x	x	x
Nwanetsi (SP)	?					x	x	x
Nwatinghala (SP)	X					x	x	?
Rhidonda (pan) closed	X							
Shivhulani (SP)	?					x	x	?
Shongile (SP)	X					x	x	?
Shivhulani (SP)	?					x	x	x
Swartklip	X							
Olifants								
Bangu (SP)	?			x		x	x	x
Bulweni (SP)	X			x		x		
Crous	X			?		x		?
Jim (SP)	?			x		x		
Ndlotini	X					x		?
Wildernis	X					x		?
Houtboschrand								

Goedegun (SP) WB in Timbavati)	🔔							x
Hamerkop (SP)	?	x		x		x	x	
Ngotso-Noord Suipkrip (SP)	?					x		x
Nyamarhi suipkrip (SP)	?							x
Peru-noord	X	x		x	?	x	x	
Peru-suid	?			x	?	x	x	
Ratelpan	🔔	x				?		x
Roodewal	🔔	x	?			?		x
Swartkop-oos (SP)	?			x		x	x	
Swartkop-wes	X			x		x	x	
Timbavati P/plek (SP)	🔔	x						x
Kingfisherspruit								
Eileen	X			x		x	x	
Fairfield	🔔	x	x					x
Houtboschrand (SP)	?			x		x	x	
Leeubron (SP)	🔔	x	x					x
Mahlabyanini	🔔	x	x					x
Mondzweni (SP)	🔔	x	x					x
N'wamutsatsa (SP)	?					x	x	x
Nwatinhlarhu	X		x	x		x		
Orpen-ruskamp	?					x		x
Rabelais	?					x		x
Red Gorten	X			x		x		
Talamati (SP)	🔔	x	x			?		x
Satara								
Girivana	?					x		x
Kambana drinking trough (SP)	X					x	x	
Mananga	🔔	?				x	x	x
Mapetane trough (SP)	X						x	
Marheya north	?			x		x	?	
Mavumbye trough (SP) (spring)	?	x				x		x
Mhisana Mond	🔔	x	x					x
Milaleni	X			x		x	x	
Muzandzeni	?					x		x

Ngotso trough (SP)	X					x	?	x
Ngwenyeni	?	?						x
Nsemani trough (SP)	?					x		x
Ntomeni trough (SP)	?					x	x	x
N'wanetsi trough (SP)	?					x		
Rizazeni trough (SP)	X					x		
Roekvale (SP)	?					x	x	x
Satara-restcamp trough	?							x
Shidzidzi trough (SP)	X						x	
Sweni trough (SP)	X					x	?	x
Welverdiend (SP)	?					x		x
Witpens trough (SP)	?							x
Shibotwana	?	x				x	x	x
Shishangani (SP)	?					x	x	x
Nwanetsi								
Gudzani (wes?) (SP)	?					x		x
Gudzani oos (SP)	?					x	x	x
Kumana	?	?	x	x			x	x
Lewerik	X					x	x	?
Marheya	X			x		x	x	
Mbhatsana (closed 1994)	X							
Mbhatsi (black rhino borehole)	?				x	x	x	
Nhlanguleni oos (black rhino borehole)	?				x	x	x	
Nsasane	X	x				x	x	x
Sonop	?					x	x	x
Nwatinungu	?							
Tshokwane								
Lugmagdam	X					x		x
Lushof	?			x		x		
Mantimahledam	X					x		x
Manzimhlope	?			x		x		x
Mazithi	?	?	?			x		x
Metsimetsi-mond	X	x	?	x				
Mlondozi	?	?				x		x

Nhlanguleni Picnic place	?					x		x
Nwatindlopfu	X					x		x
Nwatindlopfu suid (olifantdrinkgat)	?					x		x
Ribbokrand	X	?	?	x				
Rietpan	X					x		x
Sundvwini (SP)	?	x				x		
Timbetene	?	x				x		
Tinhongana	?	x				x		x
Tswaene (SP)	?	x				x		
Vutome	X	x				x		
Xiteveteve (SP)	?	x				x		
Onder Sabie								
Hillside	?	x				x		x
Loskop	?	x				x		x
Maraboepan	?	x				x		x
Mlondozi	?	x				x		x
Mafotini (Gobeni W/G) (SP)	?	x				x		x
Muntshe (SP)	?	x				x		x
Oukraal	X	x				x		
Saalbek	X	x				x		
Valsdoring	X	x			x	x		
Krokodilbrug								
Bufferdoorns (SP)	X	x				x	x	
Duke (SP)	?	x				x	x	x
Gomodwane (SP)	?	x			x	x	x	x
Jacana (SP)	X	x				x		
Mac	X	x				x		x
Nwatimhiri (SP)	?	x				x		x
Randspruit	?	x			x	x		x
Ruigtevlei	X	x				x		
Malelane								
Ampie	?	x				x		x
Biyamiti-keerwal (SP)	?	x				x		

Blinkwater	?	x				x		
James (SP)	?	x				x		x
Jock	X	x				x		x
Matjulu (SP)	?	x				x		x
Matjulwane (SP)	X	x			?	x		
Ngwenyeni	X	x				x		
Nkombanini	X	x				x		
Stolsnek								
Biyamitidam (SP)	X	x		x	?	x	x	
Komapiti (SP)	?	x		x	?	x	x	
Mavukani (SP)	X	x		x	?	x		
Mikstok (SP)	X	x		x	?	x	x	
Mlambanedam	X	x		x	?	x		
Newu	X	x		x	?	x		
Renosterpan (SP)	?	x		x	?	x	x	
Voortrekker	?	x		x	?	x	x	
Pretoriuskop								
Biyamitiwes	X	x		?		x		
Doispan Patrolliekamp (SP)	?	x				x		
Kirkman (SP)(Nyatini ft)	X	x				x		
Matlhari	?	x		x		x		
M⊥rester	X	x				x		
Shitlave	X	x				x		x
Sitfungwane (SP)	X	x		x		x		
Skukuza								
Bejwani	X	x				x		
De Laporte	X	x				x		x
Kwaggaspan	?	x				x		x
Loveday	X	x		x		x		
Manyahule	X	x				x		
Muhlabamaduba	?	x				x		x
Nhlotini (dry)	?	x		x		x		x
Nwaswitshaka	?	x				x		x
Olifantsfontein	X	x		x		x		

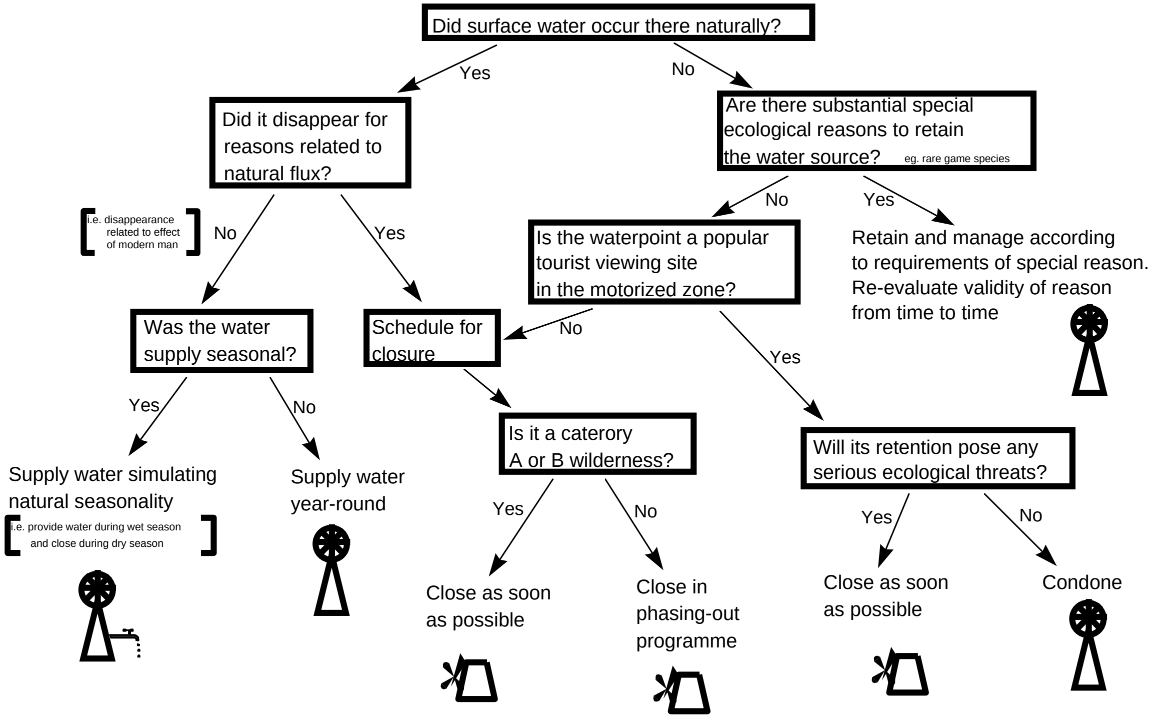
Renosterkoppies	?	x				x		x
Shipampanane	X	x				x		x
# Recommended to stay open	151							
# Recommended for closure	132							
Total	283*							

* This total only indicates boreholes used to provide water for game and not all the boreholes used for human consumption or drilled during road construction

The seven criteria used to evaluate each artificial waterpoint constituted a first stab at identifying the artificial waterpoints which were obviously placed in areas where natural water did not occur throughout the year and should be considered for closure during the first phase.

It is proposed that the following flow-diagram (Fig. 1) be used to re-evaluate all artificial waterpoints and especially those where the seven criteria could not provide clear guidelines. The flow-diagram allows a more rigorous and repeatable evaluation of each locality at which artificial water is provided.

Figure 1. Evaluation of all localities at which artificial water is provided



11. EFFECT OF THE CLOSURE OF THE IDENTIFIED ARTIFICIAL WATERPOINTS

After all boreholes have been evaluated according to the suggested criteria it is recommended that 132 boreholes be closed down during phase 1 and thus leaving 151 boreholes in operation (Table 1). Figure 1 shows the water distribution in the KNP before the closure of identified boreholes and the water distribution in the KNP after the closure is shown in Figure 2. These maps show the perennial rivers, the operating boreholes, dams that last through the dry season and the larger natural springs. It does not depict the pools in seasonal rivers.
In order to gauge the influence of water distribution in the KNP it was decided to draw buffer areas of 1 km, 5 km and 8 km around each waterpoint and calculate the percentage area of the KNP that is within 1 km of water, within 1 - 5 km of water, within 5 - 8 km and further than 8 km from water. This was calculated for before and after waterpoint closure and during normal and drought years. The results are shown in Table 2 and Figures 3 - 6.

The dams in the KNP were classified as being permanent (lasting through droughts), almost permanent (drying up in drought years) and seasonal (drying up annually at end of winter). During drought years the only water in the KNP was taken to exists as the boreholes, perennial rivers and permanent dams. For the normal years with avarage rainfall, the almost permanent dams were added. No waterholes in seasonal rivers were used in this exercise except for the ones in the Nsikazi and Phabeni Rivers on the south-western boundary. This is a high rainfall area and the waterholes are almost permanent but in the other seasonal rivers the waterholes are much more variable. Thus Table 1 and Figures 3 - 6 show the absolute **minimum** water that there could possibly occur under the four scenarios as there usually are some waterholes in seasonal rivers during normal years and even during droughts, a few waterholes will remain.

The relatively small difference in water availability during normal and drought years (Table 1), is because pools in seasonal rivers were not taken in consideration. This would increase the water distribution especially during normal years.

Before the borehole closure 82,5% of the area in the KNP is within 5 km from water and this changes to 80,6% during droughts (Table 2, Figures 3 & 4). During drought years only 4% of the area of the KNP is further than 8 km from water.

After the identified boreholes have been closed the area closer than 5 km from water changes to 67,6% during normal years and 62,9% during droughts (Table 2, Figures 5 & 6). During drought years the areas further than 8 km from water increase to 14%.

Daily journeys of up to 5 km to water seem typical for medium-sized ungulates such as wildebeest and zebra, although elephant and buffalo are capable of travelling somewhat further (Young 1970). For this reason areas closer than 5 km from permanent water are seen as dry season concentration zones, while areas further than 5 km from permanent water are seen as wet season dispersal areas. Owen-Smith (1996) suggests a 2:1 ratio of wet season/dry season range for extensive conservation areas.

As can be seen from Table 2 even in drought conditions after the suggested boreholes have been closed, the wet season range (further than 5km from water) is still smaller than the dry season range (37,2% : 62,8%). The elongated shape of the KNP and the large number of major perennial and seasonal rivers that dissect it, precludes the reaching of a 2:1 ratio of wet season/dry season range as proposed by Owen-Smith (1992). It is suggested that for the KNP one should strive for a 1:1 wet season/dry season range during drought conditions. This should ensure an adequate food reserve during drought times.

During droughts in areas with a dense, evenly spaced waterpoint distribution all grass reserves become depleted and population crashes of high density species such as buffalo can occur. This was seen during the 1992 drought in the KNP when the buffalo population crashed from 30 000 to below 15 000. If the buffalo numbers were not prevented from rising above 30 000 through culling, the crash would have been more spectacular. Buffalo is a water dependant, high density species and it is likely that with fewer evenly spaced waterpoints their numbers would not build up so high in future.

Table 2. The effect of borehole closure on the % area of the KNP at different distances from water.

Water distribution at end of dry season	**Dry season range**		**Wet season range**	
	< 1 km	**1 - 5 km**	**5 - 8 km**	**> 8 km**
Before borehole closure - during **normal** year	9,5%	73%	14,2%	3,4%
Before borehole closure - during **drought** year	9%	71,6%	15,5%	4%
After borehole closure - during **normal** year	7,1%	60,5%	22,1%	10,3%
After borehole closure - during **drought** year	6,6%	56,3%	23,2%	14%

Experience on the northern basalt plains in the KNP has shown that an even distribution of waterpoints can pose a threat to biodiversity. The more common water-dependant species such as zebra and buffalo may increase at the expense of rare species such as roan antelope. It has also been suggested that the lion population in the KNP has increased considerably, owning to the year-round availability of prey near permanent waterpoints (Smuts 1978). The rare ungulate species may thus be adversely affected by changed habitat conditions and/or predation pressure.
It is suggested that more boreholes need to be identified for closure so that dry and wet season ranges are at least equal in size. A suggested area for the closure of more boreholes is along the western boundary between the Sabie and Olifants Rivers. These boreholes were sunk to provide water for the game when the western boundary fence was erected which cut the game off from their traditional dry season watering places. This fence has now been removed and game can again move westwards during winter and thus nullifying the need for boreholes here. It is imperative that a monitoring and modelling programme to identify and assess the consequences of the proposed water distribution policy should be implemented at the same time.

Where boreholes that are tourist viewing sites are designated for closure, confrontation could possibly be offset by providing additional tourist roads to existing boreholes in the vicinity and by launching a public relations campaign to inform the public of the reasons for the closure of certain boreholes and to point out the benefits that this could have for tourist viewing. Another possibility is to reduce the size of the drinking trough so that the borehole can only support a few individual animals but does not amplify large game concentrations.

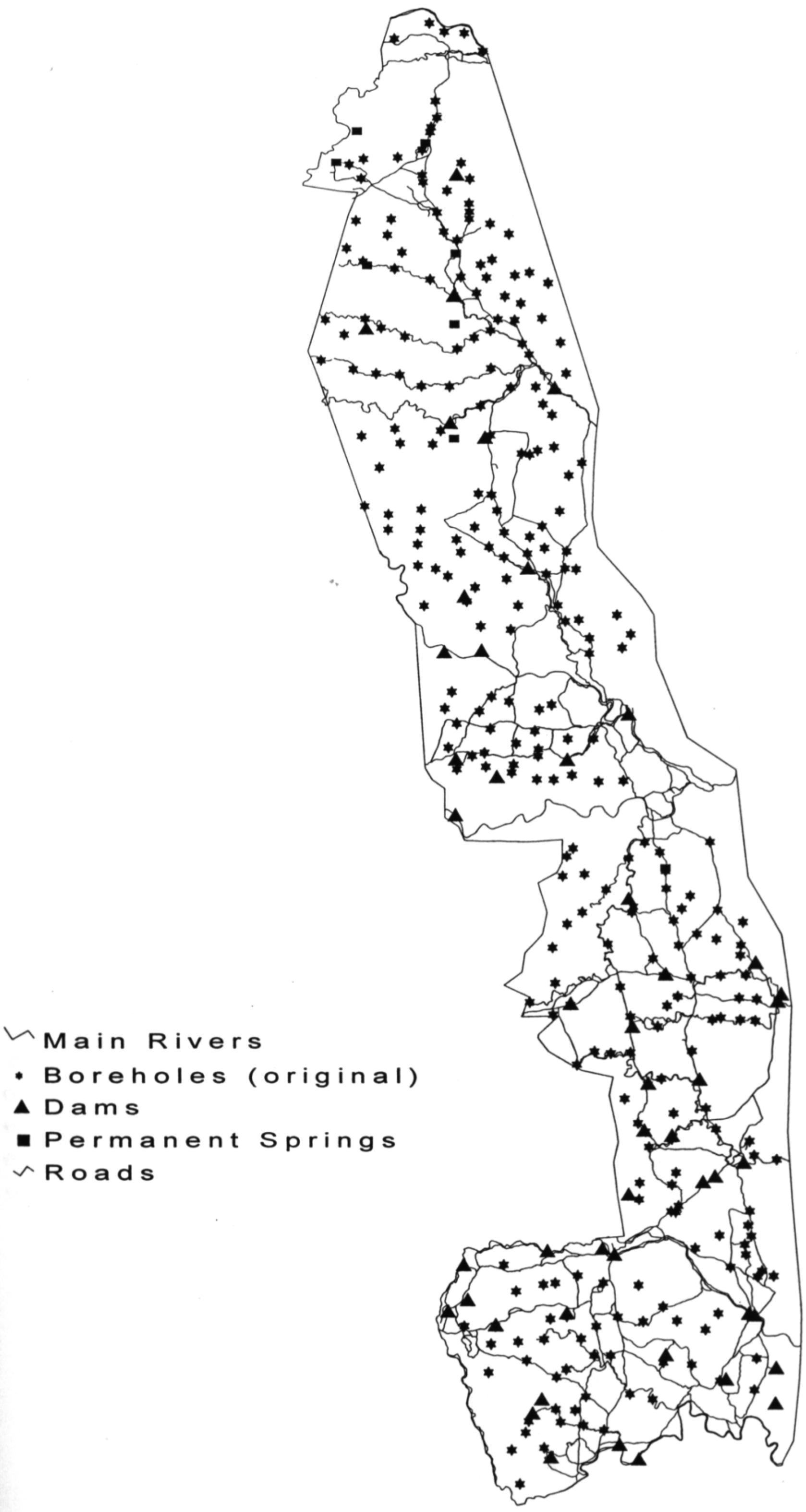


Figure 2. Present distribution of artificial and natural waterpoints in the KNP.

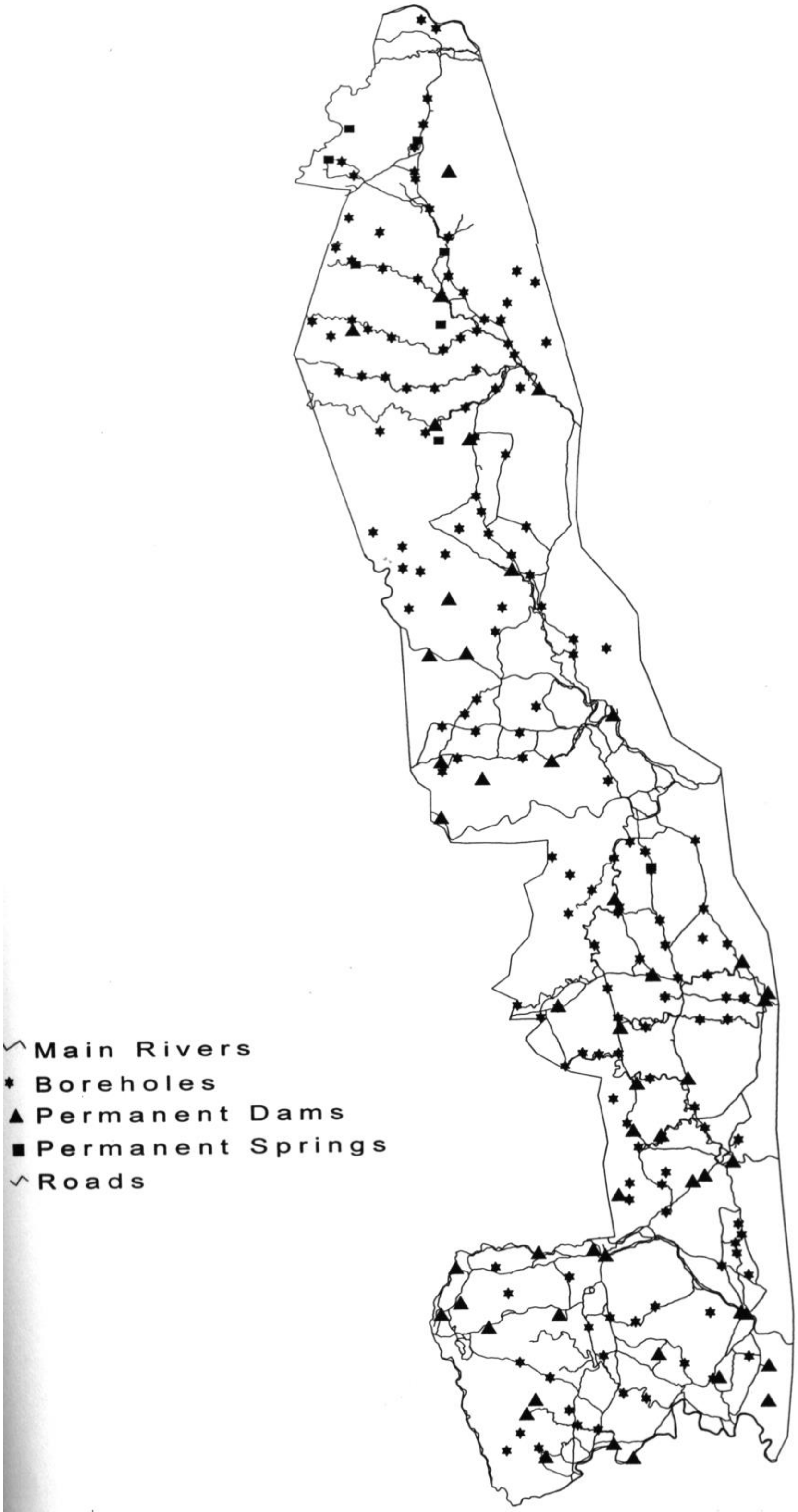


Figure 3. Distribution of waterpoints once the recommended boreholes have been closed.

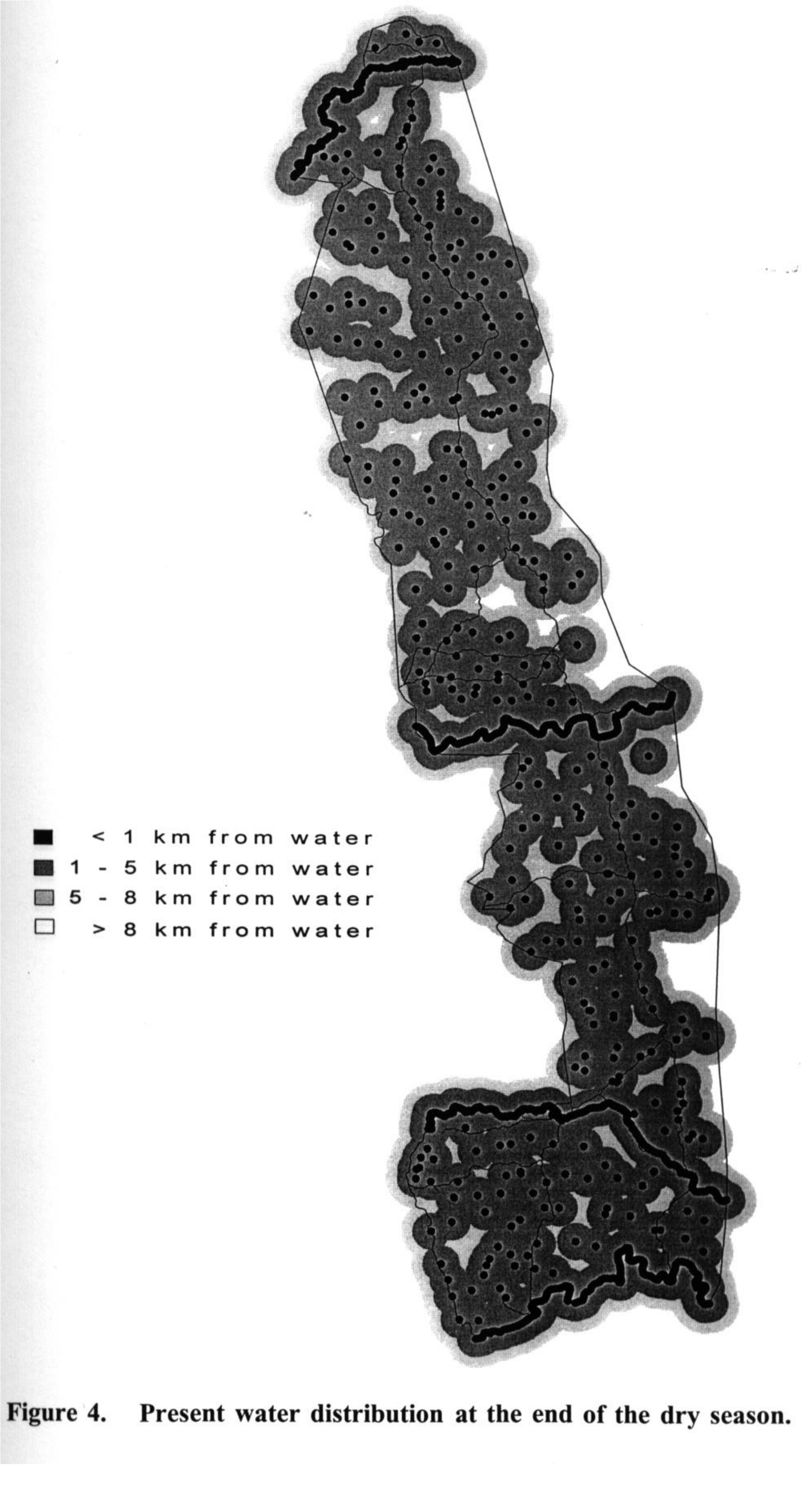


Figure 4. Present water distribution at the end of the dry season.

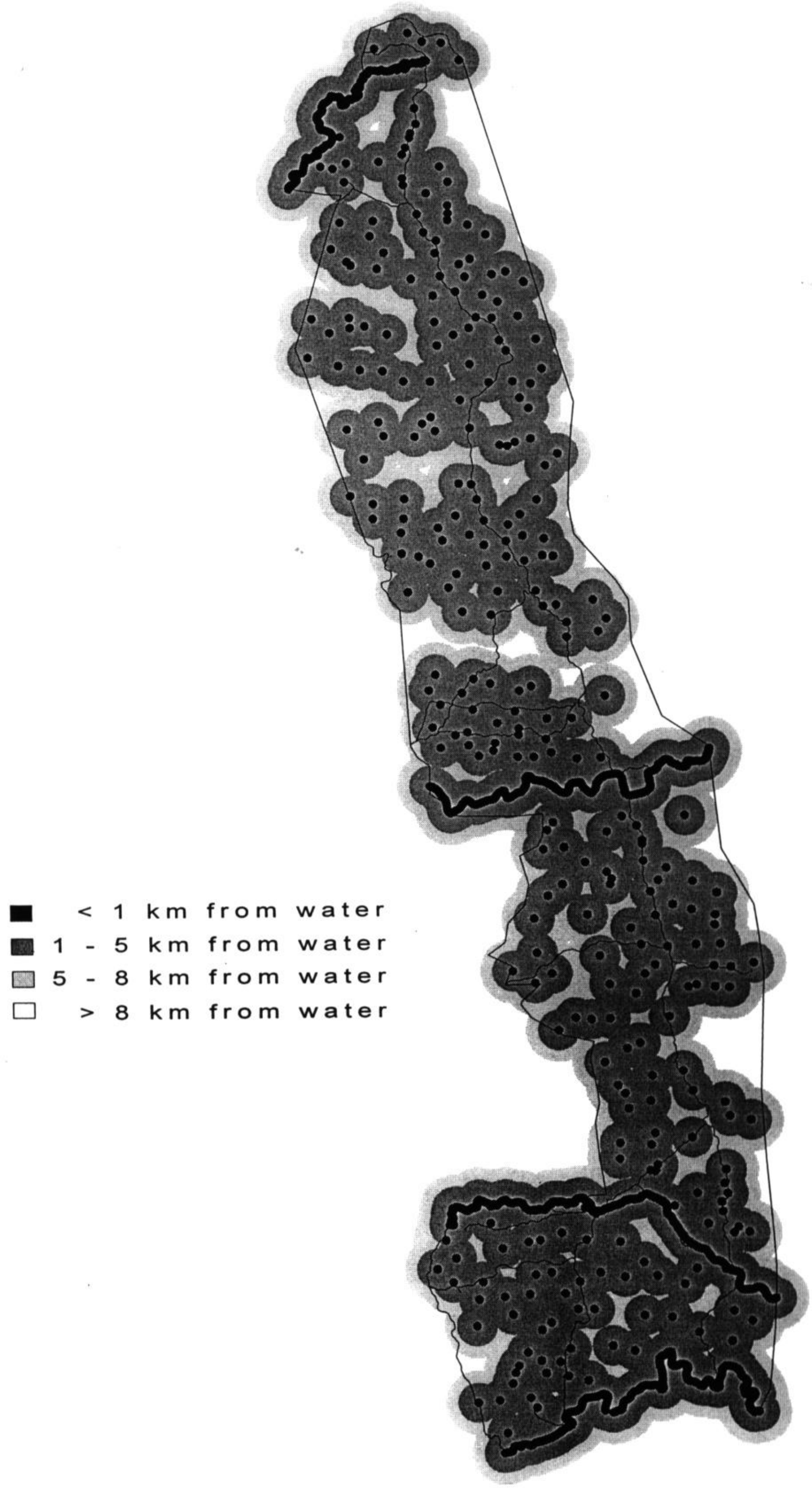


Figure 5. Present water distribution during a drought.

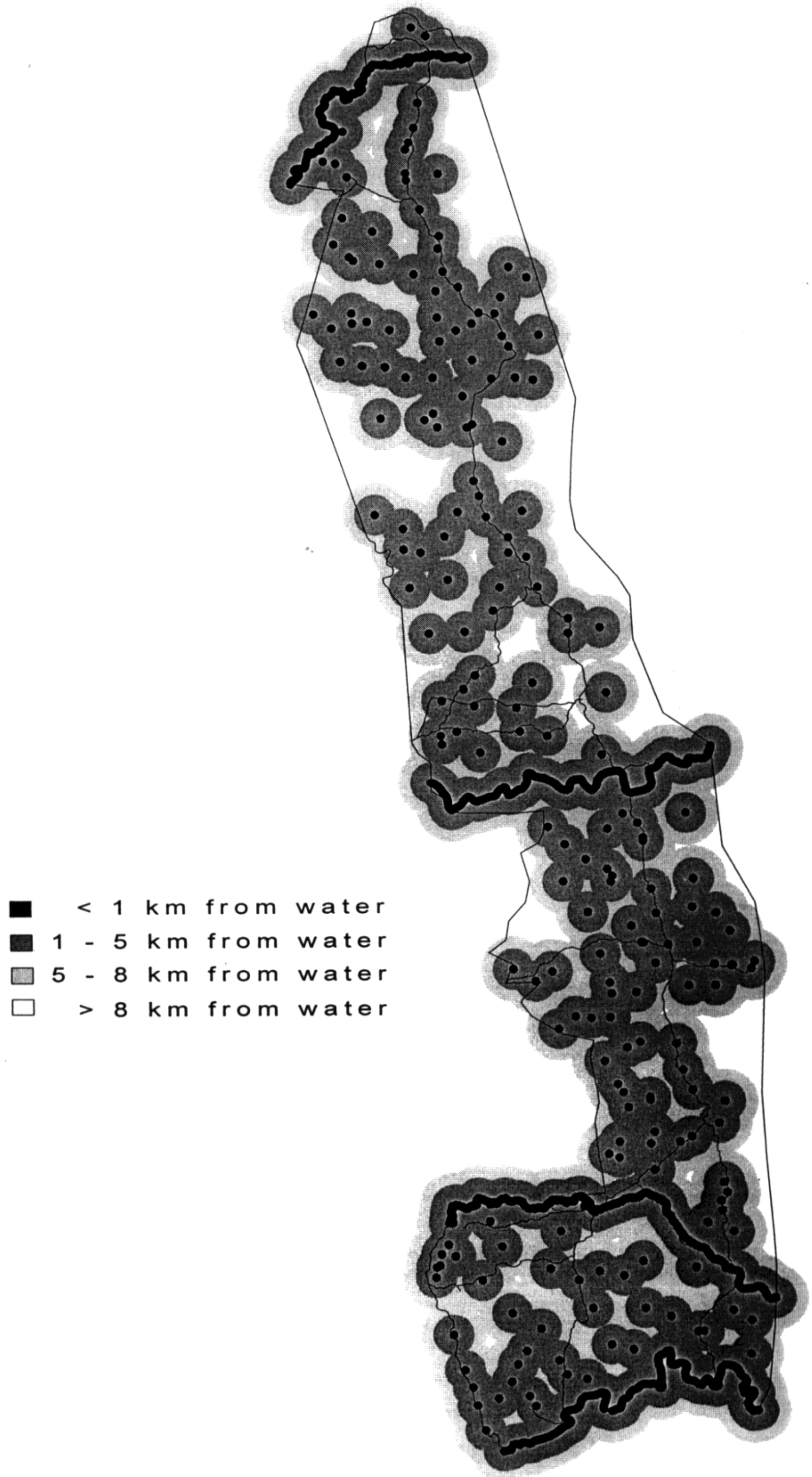


Figure 6. **Water distribution at the end of the dry season once the proposed boreholes have been closed.**

FIG 7 SHOULD BE HERE

12. GENERAL MANAGEMENT OF ARTIFICIAL WATER

It is necessary that all artificial waterpoints (existing ones and new boreholes) be evaluated according to the above criteria. The artificial waterpoints that are deemed to be essential need to be managed with ecological processes as a guideline. For example, natural water holes in seasonal rivers close and open up according to the intensity of run-off. Where there are a number of boreholes along a seasonal river, some could be temporarily closed for a season or two and then opened again. This will reduce continious game concentration around some boreholes.

To achieve this it would be necessary to do away with the present reservoir and trough design. Consideration should be given to constructing a single large natural-shaped trough which can hold more water and would not crack when standing empty for a season or two.

Consideration can be given to closing approved boreholes during a good rain season in order to conserve underground water and prohibiting trampling around the waterpoint. Clearly this would only be undertaken if the waterpoint is at a location where there would not normally be water through the year.

Providing water on vulnerable soils such as brackish soil or against easily erodible slopes should be avoided. It is unlikely that natural water would have been in these locations on a permanent basis.

If there is a need to put a mechanical pump on a borehole stay within the prescribed rate and time for that borehole. To improve effectiveness the combination of windmills and solar pumps or solar pumps with an increased capacity should be investigated.

13. DAILY MANAGEMENT OF ARTIFICIAL WATER

1. All key artificial waterpoints need to have two drinking troughs or a large natural shaped trough.

2. Filling in with soil must be done regularly at reservoirs and troughs to protect the construction and combat forming of gullies.

3. The growth of trees and shrubs within 20 m from a borehole must be prevented as the roots can clog the pipes.

4. Shrubs around tourist troughs should annually be cleared to a distance of 50-60m to enhance game viewing.

5. Repairs and erosion prevention should be undertaken regularly on entrance roads to waterpoints.

6. All entrance roads to boreholes that are closed down must be ripped up and made erosion-resistant.

14. CONCLUSIONS

This revised water-distribution policy for the KNP is aimed at assisting in the restoration of intrinsic biodiversity at the landscape level through the simulation of the natural availability of water. The principles mentioned give guidelines for the provision of artificial water and necessitate the re-evaluation of all artificial water-points using stated criteria and the phased removal of artificial waterholes which do not comply with such criteria.

It also necessitates a monitoring programme to assess the consequences of the proposed water distribution policy. Monitoring and modelling is also required in order to predict effects so that Management policy and actions can be continually be refined.

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