320

oppdragsmelding

The North-South Carrier Water Project in Botswana

A review of environmental impact assessments

Kjetil Bevanger

NINA

NORSK INSTITUTT FOR NATURFORSKNING

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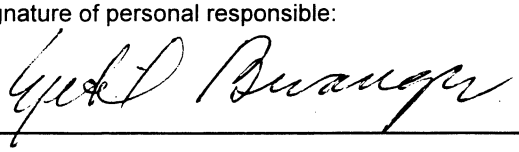

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Abstract

Bevanger, K. 1994. The North-South Carrier Water Project in Botswana. A review of environmental impact assessments. - NINA Oppdragsmelding 320: 1-25.

Existing information on environmental impact assessments relating to the North-South Carrier Water Project (NSCWP) in Botswana has been reviewed. There are two major environmental encroachments and artificial constructions connected with the NSCWP: (i) the building of an 18 km^2 reservoir (Letsibogo Dam, with an active storage of 100 Mm^3) on the Motloutse River, about 70 km south of Francistown, and (ii) the building of a 361 km long water transfer pipeline from the reservoir to 15 km north of Gaborone. In general, the environmental studies carried out in connection with the pipeline and reservoir seem to comply with the standards called for by, for instance, NORAD, and the proposed mitigating measures as well as the recommendations for management action are in agreement with current ecological knowledge. Although they do not guarantee that future problems will be avoided, if they are followed carefully it is thought that the negative environmental effects of the project will be held at a tolerable level. The impacts of **pipeline** construction (buried in the ground) on the land surface will be mitigated by carefully removing the vegetation across the width of the future trench, stripping and separately stockpiling the topsoil, subsequently replacing the soil layers in the correct order immediately after laying the pipe. Together with the cleared scrub preserved on top of the stockpiled soil, the seed bank in the topsoil is expected to be adequate for ensuring regrowth. The **Letsibogo Dam** is planned as a 28 m high rock-filled dam across the Motloutse River, an ephemeral sand river, i.e. surface flow occurs only during the rainy season. A comprehensive EIA has been carried out in connection with this dam project, and it is particularly satisfying to note that the need is pointed out for a broad range of monitoring and follow-up studies in connection with the project, both in the reservoir area and downstream from the dam. It is crucial that these studies are put into practice. However, the project is a typical example of the need for international standards for EIA studies to determine the qualitative and quantitative criteria that need to be upheld in such scientific investigations.

Key words: EIA - encroachment - conflicts.

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Referat

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Miljøkonsekvensanalyser utført i tilknytning til et vannrørledningsprosjekt i Botswana (The North-South Carrier Water Project, NSCWP er evaluert. De to største naturinngrepene knyttet til prosjektet består i bygging av et 18 km^2 stort vannreservoar (Letsibogodammen, med en magasineringskapasitet på 100 Mm^3) i Motloutseelva, ca 70 km sør for Francistown og bygging av en 361 km lang vannrørledning fra reservoaret til en inntaks- og balanseringsdam ca 15 km nord for Gaborone. Miljøkonsekvensanalysene som er utført i tilknytning til rørledningen og reservoaret er generelt i tråd med de standarder som bl.a. er indikert av NORAD, og de foreslåtte avhjelpende tiltak er i tråd med eksisterende økologisk forståelse og kunnskap i forhold til denne type naturinngrep. Selv om tiltakene ikke representerer noen garanti for fremtidige miljøproblemer, antas de, hvis de blir fulgt opp nøye, å kunne redusere negative miljøkonsekvenser til et tolererbart nivå. Negative effekter av **røredningen** (som blir gravd ned) på jordoverflaten vil reduseres gjennom en nøye kontroll av hvordan jordsmonn og vegetasjon blir fjernet over grøfta. Det øverste jordlaget og vegetasjonen fjernes og lagres separat og vil bli lagt tilbake til slutt når anleggsarbeidene er avsluttet. Frøbanken i det øverste jordsmonnet, sammen med den opprinnelige vegetasjonen, antas å være tilstrekkelig for å oppnå adekvat revegetering slik at erosjonsproblemer unngås i ettertid. **Letsibogodammen** er planlagt som en 28 m høy jord- og steinfyllingsdam i ei såkalt sandelv (Motloutse), det vil si at elveleiet er tørt unntatt enkelte perioder i regntiden. En omfattende miljøkonsekvensanalyse er utført i tilknytning til damprosjektet, og det er spesielt tilfredsstillende å konstatere at en rekke overvåkningstudier for å følge fremtidig utvikling i forhold til miljøet, er foreslått, både for selve reservoaret og nedstrøms dammen. Det er avgjørende at disse tiltakene følges opp og settes ut i livet. De utførte konsekvensanalysene viser imidlertid at det er behov for internasjonale standarder som kan definere faglige kvalitative og kvantitative kriterier for hvilke miljøundersøkelser slike prosjekter krever.

Emneord: EIA - naturinngrep - konflikter.

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Preface

The Government of Botswana is currently planning to develop its water resources to meet domestic and industrial needs as part of a National Water Masterplan. To cover future needs in the southern area, including the capital Gaborone, it is proposed that the North-South Carrier Water Project (NSCWP) will bring water from a planned reservoir about 360 km north-east of Gaborone. From 20 November to 2 December 1994, NORAD, together with the Nordic Development Fund (NDF), the Nordic Investment Bank (NIB) and the Swedish Board for Investment and Technical Support (BITS), participated in an Appraisal Mission to Gaborone to consider financial support for the project. However, these organisations were concerned about the possible environmental consequences of the proposed project and therefore wanted an environmental specialist to participate in the mission to review existing information on the environmental impact assessments of the project. At the request of NORAD, the Norwegian Institute for Nature Research took on this task. I want to thank Alan Cave, Paul Larkin, Moremi Sekwale, Eugene Shannon and representatives of ADB, BITS, EIB and NORAD for fruitful discussions and constructive cooperation during the mission.

Trondheim, December 1994

Kjetil Bevanger

Content

1 Introduction

1.1 Background

The National Water Masterplan (NWMP) for Botswana has identified short-term and long-term needs for water supply for domestic and industrial use (e.g. SMEC et al. 1992a). The Masterplan Studies were carried out between August 1989 and June 1992, and the findings, both for a Phase I and a Phase II, and manuals for computer models, are given in a series of Masterplan Reports, of which SMEC et al. (1992a) is an executive summary. Volume 4 in the series of reports dealing with Phase I handles environmental aspects (SMEC et al. 1992b, c).

Both groundwater and surface water resources in Botswana are very limited. The total volume of surface runoff is low and varies a great deal over time, droughts sometimes lasting for years. Groundwater being drawn from water that accumulated in a wetter era in the remote past is referred to as "groundwater mining", as it is a non-renewable resource (SMEC et al. 1992a).

Botswana, located in the interior of the African continent and remote from marine influences, has no pronounced spatial climatic variations as there are no major mountain ranges. Annual rainfall varies from about 250 mm in the south-west to about 690 mm in the north-east. Rainfall is highly seasonal with about 90% occurring between October and April, when evaporation is at its maximum. The annual average evaporation countrywide is about 2000 mm. The mean annual number of days with rainfall varies from 25 to 55. Apart from three months in winter, temperatures are high with an average daily maximum temperature in excess of 30 °C from October to March over most of the country (SMEC et al. 1992a).

The northern part of the country, including the Okavango area, is better off for water supplies than the southern and eastern districts where most of the economic activity occurs and much of the population lives. In particular the Gaborone area in the southern part of Botswana, which accounts for some 80% of the total water consumption, has a high growth rate with a corresponding increasing need for water.

Socio-economic studies have concluded that Botswana has both a high economic growth and a high rate of urbanisation. At present, the national population is close to 1.3 million and the predicted population for 2020 is 3 million, i.e. 3.4% growth per annum. The Gaborone area now has a population of about 130 000, and 550 000 is forecasted for 2020, i.e. 9% growth per annum. **Figure 1** gives the present and future water requirements for different types of settlement and per capita.

1.2 The North-South Carrier Water Project (NSCWP)

In general, the flat terrain and other aspects of the physical geography mean that there are few possibilities for storing water in Botswana. However, the NWMP identified the most promising storage sites in the north-east of the country, about 400 km from the main centres of demand in the south-east (SMEC et al. 1992a). Such sites are found in connection with small, ephemeral (i.e. seasonally flooding) rivers, tributaries of the Limpopo River, e.g. the Motloutse and Shashe rivers (**Figure 2**). Because of this, a plan to transfer water has been developed, known as the North-South Carrier Water Project (NSCWP).

This report results from the possible participation by several Nordic agencies in the funding of the NSCWP and their desire for a review of the environmental aspects connected with the environmental disturbances which necessarily have to take place. At the North-South Carrier Water Project Donors Conference (NSCWPDC) in Gaborone, Botswana, on 27-29 June 1994, NORAD pointed out that "EIA should, in general, comply with Norwegian guidelines". The terms of reference (TOR) for the mission are given in **Appendix 1.**

The field work for the present report was carried out in late-November 1994, and the reflections and conclusions are mainly based upon detailed consideration of existing environmental reports and discussions with officials in WUC and with the environmental consultants involved. The suggested reservoir site was visited and a two-day trip was made along the proposed pipeline route.

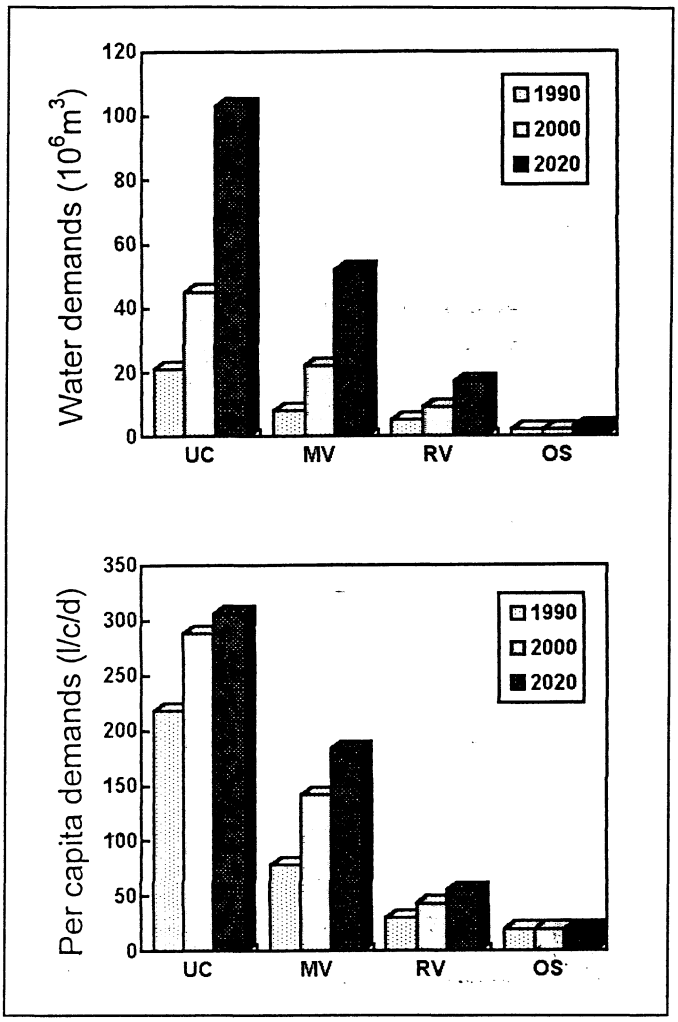

Figure 1. Water demands in Botswana in 1990, 2000 and 2020 for different settlement types, and per capita. UC = urban centres, MV = major villages, RV = ural villages, OS = other settlements (based on SMEC et al. 1992a).

2 Project plan summary and environmental documentation

The NSCWP entails two major environmental encroachments and artificial constructions: (i) a reservoir on the Motloutse River (Letsibogo Dam), and (ii) a water transfer pipeline. However, the project is divided into two construction phases, Phase II including another pipeline and another reservoir (**Figure 3**).

In short, Phase I includes the construction of an approximately 360 km long transfer pipeline from the proposed Letsibogo Dam on the Motloutse River south to a treatment works and Master Balancing Reservoir (MBR) near the boundary between the Kgatleng and South East Districts, approximately 15 km north-east of Gaborone. In the second phase, a duplicate pipeline will be constructed to connect a dam on the Sashe River (Lower Sashe Dam) with the same treatment works and reservoir. Initially, the first pipeline was planned to be connected to the Bokaa Dam, which is one of the water resources currently available to Gaborone (together with the Gaborone Dam, the Molatedi pipeline and the Ramotswa wellfield). However, to avoid water loss through evaporation, the plan now envisages a new, covered MBR construction closer to Gaborone. Construction of Phase I is due to commence in 1995 with completion in 1999. The timing of Phase II is uncertain and subject to further engineering and economic studies, but the Lower Sashe Dam will probably be required in about 2005, the second pipeline being built some 5 or 10 years later.

As land for the pipelines is being acquired simultaneously for both phases (except that required for the Phase II pipeline between the Lower Sashe Dam and the Phase I pipeline), the environmental studies have considered the pipelines of both phases, but not in detail in the case of Phase II.

The Phase I pipeline is planned to have a diameter ranging from 1100 mm to 1400 mm and will probably be made of glass-reinforced plastic and ductile iron. It will be buried in the ground and is designed to convey raw (untreated) water. It is estimated that the pipeline will transfer 15.9 million m^3 of water per year in 1999 (WUC 1994a). The pumping station at the dam will have a capacity of 1200 l/sec. In connection with the pipeline it will be necessary to build several sections of road, 4 pumping stations, 4 break pressure tanks, 3 treatment works and an MBR.

The Letsibogo reservoir is planned to be contained by a 28 m high rock-filled dam. The crest of the wall will be at a height of 856.8 m a.s.l. The dam filling will have a volume of 1.42 Mm^3, including a 300 m crest-length, ungated spillway with a probable maximum flood (PMF) capacity of 11 850 m^3 per second, although this capacity is still being evaluated. The reservoir will have an active storage capacity of 100 Mm^3, from which the estimated yield in the Motloutse River at this site is 24.1 Mm^3. The crest length of the dam will be 1270 m and the reservoir will have a drawdown of 13 m. At full supply level (848.8 m a.s.l.), the reservoir will cover 18 km^2. However, when flooding occurs it could cover 21.66 km^2. The catchment area for the reservoir is 5693 km^2.

In addition to the general environmental aspects relating to water supply requirements in Botswana, dealt with in the NWMP (SMEC 1991b), specific ones concerned with the Letsibogo Dam and the transfer pipeline are considered by Cave Klapwijk and Associates (Cave 1994) and Environmental Consultants, Gaborone (Larkin 1994), respectively. In 1990, a feasibility study was made for the "Motloutse Dam" (MacDonald 1990). The final report for the pipeline study will be available in mid-December 1994 (P. Larkin, pers. comm.). However, a "Significant Issues Report" from November 1994 has been available. The final report for the Letsibogo Dam was finished in March 1994.

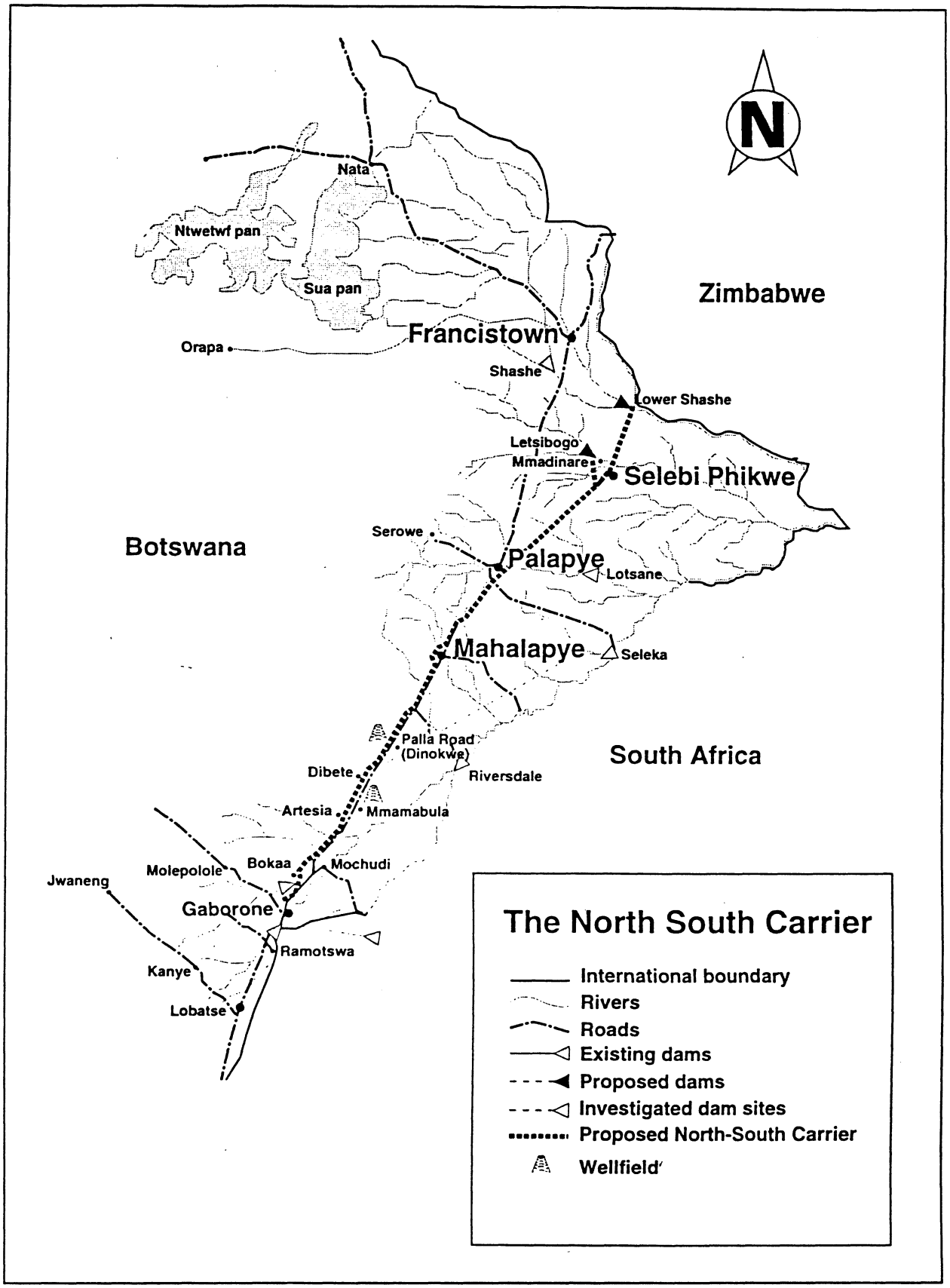

Figure 2. The North-South Carrier Water Project in Botswana plan to take water from a reservoir about 70 km south of Francictown to the Gaborone area.

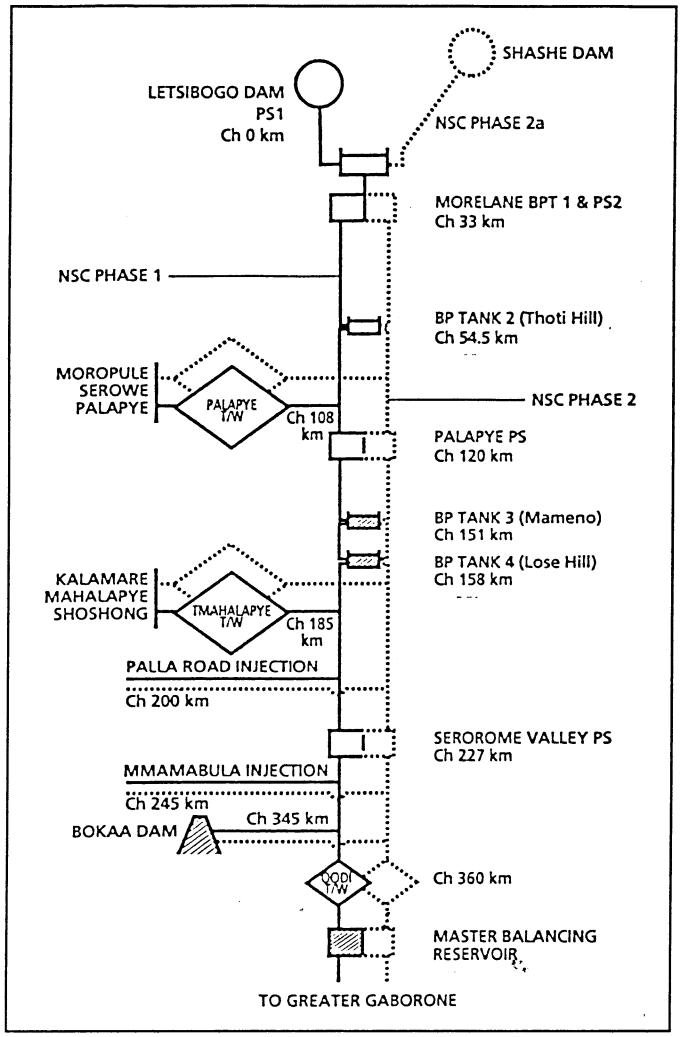

Figure 3. The North-South Carrier Water Project (after WUC 1994c)

The main environmental studies made by the consultants regarding the dam and the pipeline (Cave 1994, Larkin 1994) comprise a wide spectrum of topics.

The environmental pipeline studies focus on the following aspects:

(a) Land resources and utilisation
(b) Archaeological sites
(c) Construction impacts on the land surface
(d) Others - which comprise

  (i) Flora and fauna
  (ii) Sand rivers
  (iii) Waste-water management in supply areas

The land acquisition and compensation requirements are considered to be the most important issues (Larkin 1994).

According to the TOR, the Letsibogo Dam studies should focus on the following issues:

(a) impacts on fauna and wildlife
(b) impacts on water quality downstream of the dam wall
(c) impacts on the aquatic ecosystem
(d) impacts on the archaeological remains in the dam basin
(e) impacts on the social environment, particularly compensation and relocation requirements for people displaced by the dam
(f) impacts on human and animal health
(g) impact of the dam on the pollution potential in the Motloutse River

Because of the TOR for the present mission (**Appendix 1**) and my own professional qualifications, this report only focuses in any detail on the ecological aspects of the project.

2.1 The pipeline

From the Letsibogo Dam the pipeline will run adjacent to the proposed Letsibogo Dam access road, passing round the village of Mmadinare to follow the existing road to Mmadinare from the Serule/Selebi-Phikwe road (0-16 km). It will then follow the BPC 220 kV power line in a south-westerly direction (16-69 km) bypassing Palapye to run parallel to the Gaborone-Francistown railway under the road to Martins Drift (69-115 km). It will then be located adjacent to the Gaborone-Francistown railway reserve as far as the Makoro Pump Station (115-120 km), before following the same railway to the Tewane Siding south of Radisele (120-148 km) where it will pass just south of Lose Hill and cross the railway and main road before Lose Siding (148-161.5 km). From a point north of Lose Siding, it will be located adjacent to the Gaborone-Francistown main road reserve to a point north of Mahalapye (161.5-168 km) and run cross-country near the BPC 220 kV power line to pass round the western outskirts of Mahalapye (168-191 km). It will then run adjacent to the Gaborone-Francistown main road reserve from a point south of Mahalapye to Serome Pump Station (191-230.8 km) as far as a point north of Rasesa village (230.8-336 km) and then continue cross-country west of the Gaborone-Francistown road west of the Morawa Hills and close to the existing WUC Bokaa Dam and across to the inlet of the north Gaborone treatment works (336-361.2 km).

Thus, the pipeline will largely be located close to, and within the reserves of, the existing road and railway. Where no such possibility exists, a permanent access road will be built adjacent to the pipeline. This may be up to 100 m from the pipeline as long as it is possible to reach it when needed. In general, however, the plans indicate that a 50 m wide strip will be affected during the construction phase. In addition, permanent roads will be built in connection with all surface installations such as treatment works, pumping stations and break pressure tanks.

The pipeline is routed within an area characterised by a "fairly high degree of topographic, geological, pedological and biogeographical uniformity", and ecological zones, units and subunits are in general thought to be very much larger than the

working width of the pipeline (Larkin 1994). In eastern Botswana, settlement is relatively intensive, with arable agriculture and livestock grazing.

2.1.1 Vegetation

Vegetation maps have been prepared for the whole pipeline route. A map for the Central District has been compiled using existing data, satellite imagery interpretation and reconnaissance field surveys. Thus, earlier mapping along the route from the southern boundary of the Central District to the Greater Gaborone area has been extended using existing sources of data and extensive field surveys (Larkin 1994).

The following vegetation types (at association level) have been identified and described by Environmental Consultants:

Bare pan surfaces
Burkea/Ochna savanna
Acacia erioloba savanna
Kirkia/Commiphora woodland
Rocky hill woodland
Acacia savanna
Acacia nigrescens/Acacia nilotica woodland
Colophospermum mopane/Acacia woodland
Colophospermum mopane on shallow soils
Colophospermum mopane on sandy soils
Colophospermum mopane shrubland
Riverine vegetation

2.1.2 Fauna

Mammals, birds, reptiles and amphibians have been considered. It was not judged imperative to carry out original faunal surveys in connection with the pipeline. However, the entire length of the proposed route has been investigated in the field for unique wildlife habitats which the planned constructional work might put at risk. Other information relating to the project has been obtained from existing literature and from consultation with local experts (Larkin 1994).

Insects and microfauna have not been subjected to any analyses.

For each species, the following important attributes as regards conservation status have been considered:

(i) relative abundance, both within Botswana and regionally

(ii) geographical distribution and availability of suitable habitats nationally and regionally

(iii) global conservation status as assessed by IUCN

Mammals. Wildlife densities in the eastern hardveld area are generally low due to long-term settlement, infrastructural development and land use (Larkin 1994). Of the 30 large herbivore species censused countrywide, five are widespread at low to moderate densities within the project area (i.e. common duiker, steenbok *Raphicerus campestris*, kudu *Tragelaphus strepiceros*, impala *Aepyceros melampus* and klipspringer *Oreotragus oreotragus*). Altogether about 75 species might be expected to occur in the vicinity of the pipeline route, most of them being small species (< 5 kg).

Of the four mammalian species occurring in eastern Botswana and listed by IUCN as being globally threatened (i.e. South African hedgehog *Atelerix frontalis*, brown hyena *Hyaena brunnea*, African elephant *Loxodonta africana* and Woosnam's desert rat *Zelotomys woosnami)*, only the hedgehog is likely to occur as a regular resident in the vicinity of the project area (Larkin 1994).

Birds. The pipeline route crosses areas where approximately 250 species are expected to be found, 215 of which are resident, breeding species. Most of these are common in appropriate habitats. The Cape vulture *Gyps coprotheres* is considered by IUCN to be threatened, electrocution in connection with power lines being the most frequent mortality factor and threat to the species (Ledger & Annegarn 1981).

Reptiles and amphibians. The Botswanian herpetofauna is poorly known and has only been rudimentarily studied. Thus, the conservation status of most taxa has not been evaluated. About 60 species are thought to exist in the project area. None of these are known to be threatened internationally (Larkin 1994).

Between 10 and 20 amphibian species may occur in the project area, but as for reptiles the distribution of most taxa is unknown and many habitats, especially those required for breeding, are ephemeral. None of the species expected to be in the area are classified as threatened nationally or internationally (Larkin 1994).

2.1.3 Other aspects

Because of land tenure, land acquisition and socio-economic aspects are, in general, very important issues in connection with environmental encroachments in Botswana. The study has therefore dealt commendably thoroughly with this. Particular attention is also given to archaeology and some of the best specialists in Africa have been used as subconsultants on that part of the study (P. Larkin, pers. comm.).

Waste-water management in the supply areas is briefly considered. Sanitation and waste-water management have so far been the responsibility of the Ministry of Local Government, Lands and Housing (MLGL&H) whereas responsibility for developing water resources has lain with the Ministry of Mineral Resources and Water Affairs (MMRWA). However, the increased importance of waste water as a resource and recognition of the necessity for having water-borne sewerage in major settlements has lead to a revision of this division of responsibility. The future situation seems likely to be that the

water supply authorities will also be responsible for sewage management.

A Gaborone Sewerage Masterplan Study has recommended the construction of a conventional treatment plant to become operational in 1995. Treated effluent from the plant will initially be used for irrigation purposes while experience on quality control is being gained. In the long term, recycled water will be used to augment supplies to the city in order to postpone development of new resources, e.g. delay the need for the implementation of Phase II of the NSC (Larkin 1994).

2.2 Evaluation of the study and the degree of documentation

In general, the environmental studies carried out in connection with the pipeline seem to comply with the standards desired by, for instance, NORAD (1990). However, the documentation so far available makes it difficult to quantify the efforts made in the field and judge to what extent the methods used are in accordance with international scientific standards.

Vegetation. Vegetation mapping frequently takes place when total habitat destruction is expected. Since vegetation maps will be an appendix to the final report, it is expected that this subject has been properly considered.

Fauna. Many of the "facts" seem to be based on assumptions. Expressions like "potentially" existing species are frequently used, indicating that the knowledge is based on general zoogeographical information from the literature. It should be pointed out that this type of information should not be considered sufficient when an EIA is being made regarding a specific local encroachment. In the case of birds for example, a more appropriate approach would have been to select a number of plots in representative habitats along the pipeline route and use a method which could have given both a qualitative and a (semi)quantitative picture of the avifauna present, e.g. point counts or mist net catching.

Lists of species found in the area affected by primary and secondary pipeline activities are not being reproduced in the final environmental impact assessment as these were judged to "merely add bulk to the final report without providing the client with information of substantial content" (Larkin 1994). Species lists should be given as they may be valuable information for biologists in other connections. However, if specific reports on the various topics are available and are accompanied by species lists, the final report need not include them.

Overall, the impression remains that, despite considerable effort, more systematic, comprehensive field work should have been carried out in the zoological part of the study, using standardised methods for qualitative and quantitative mapping of the occurrence of species in the area. In particular, efforts should have been made to identify reptiles and amphibians.

To the best of my knowledge, the socio-economic and archaeological issues seem to have been handled in a particularly outstanding way. The support given to the plan for a joint governmental unit to take care of both water supply, sanitation and sewerage operation is also important.

2.3 The Letsibogo Dam

The Letsibogo Dam wall is expected to be located approximately 3 km upstream from the village of Mmadinare, about 70 km south of Francistown. The climate in the area is tropical and semi-arid with seasonal rainfall from November to March, 90% of the mean annual rainfall falling during this period. The mean annual precipitation may range from about 450 mm in the upper Motloutse catchment area in the west to about 340 mm in the east at the Motloutse/Limpopo confluence. However, it is extremely variable and rainfall amounting to less than 40% of the mean annual precipitation can be expected one year in seven (Cave 1994).

Most of the upper catchment area of the Letsibogo Dam has a low erosion hazard. However, the area north of the Motloutse River in the lower catchment area is vulnerable to erosion because of neighbouring drainage lines, inherently erodible soil or steep topography (Cave 1994).

The Motloutse is an ephemeral sand river, i.e. surface flow occurs only during the rainy season, until April or May. However, low subsurface flow continues throughout the rest of the year. Water flow in a sand river is even more complicated than in a free-flowing river; for instance, pollution plumes can extend many kilometres downstream before complete mixing is attained (Cave 1994).

The EIA studies undertaken have used the principles of IEM, i.e. Integrated Environmental Management, developed by the South African Department of Environmental Affairs. "IEM is a procedure for guiding the development process. The object of following the IEM procedure is to integrate environmental considerations into all stages of the planning and development process in order to achieve the benefits of developments with minimal harm to the environment. - The IEM approach is not an alternative to EIA, but a methodology for environmental assessment which conforms to World Bank requirements" (Cave 1994).

According to his TOR, the consultant was expected to review the feasibility and preliminary design studies (MacDonald 1990) of the vegetation and fauna/wildlife. This review indicated that the impact on vegetation and fauna (except reptiles) "was considered in sufficient depth to make final conclusions on the mitigation of impacts on these aspects" (Cave 1994). Thus, the final EIA report contains no specific assessment of the impact on other faunal elements than reptiles and no assessment of floral elements or impact on vegetation.

2.3.1 Vegetation

A vegetation map has been prepared for the reservoir area and was included in the MacDonald (1990) report.

The vegetation in the project area is termed Mixed Mopane/Acacia Tree Savanna, and the dominant tree species of this regional vegetation formation is *Colophospermum mopane*, but there are many subtle variations on a local scale, reflecting complex interactions between several environmental and biotic factors (MacDonald 1990).

During the survey, 256 plant species were identified, 126 of which were collected and prepared as herbarium specimens at the National Herbarium in Gaborone. Over 200 species were recorded from the proposed reservoir area, and 134 from areas downstream. "Further collection would undoubtedly reveal additional species" (MacDonald 1990).

The following vegetation types (at association level) have been identified and described within the reservoir area:

Communities of granite-gneiss hills and rocky ridges
- Open Woodland (*Commiphora marlothii-Croton gratissimus*)
- Closed Woodland (*Commiphora-Kirkia acuminata*)

River and stream bank communities
- Dense Riverine Woodland (*Combretum erythrophyllum-Acacia karroo*)
- Riparian Woodland (*Combretum hereroense-Peltophorum africanum*)

Acacia-dominated communities of bottomlands
- Woodland (*Acacia tortilis-Boscia albitrunca*)
- Open Woodland (*Acacia mellifera-Acacia tortilis*)
- Woodland (*Acacia erubescens - Combretum apiculatum*)

*Colophospermum mopane*dominated communities of the uplands
- Woodland (*Colophospermum mopane - Acacia nigrescens*)
- Woodland (*Colophospermum mopane - Combretum apiculatum*)
- Woodland (*Colophospermum mopane*)
- Scrubland (*Colophospermum mopane - Commiphora pyracanthoides*)

Communities of occupied and abandoned land
- Regenerating *Acacia tortilis* Thicket
- *Grewia* spp. Scrub

Minor communities
- Scrubland (*Catophractes alexandrii - Rhigozum brevispinosum*)
- Communities of seasonally waterlogged depressions and drainage lines

2.3.2 Terrestrial fauna

Mammals and birds are considered by MacDonald (1990) and reptiles and amphibians by Cave (1994). Insects and microfauna have not been subject to any analyses. The conservation status of the species connected with the reservoir area has been considered using the same criteria as described in section 2.1.2.

Mammals. Up to 28 species of large mammals may have occurred in the area in the recent past. Some of these, e.g. the lion *Panthere leo*, wild dog *Lycaon pictus* and hippopotamus *Hippopotamus amphibicus*, are now locally extinct (MacDonald 1990). Only a few ungulates were recorded: steenbok, impala, kudu and klipspringer. A small herd of elephants lives in the area, varying between 35 and 60 animals.

Most of the smaller mammals are nocturnal and were not surveyed. The most common diurnal mammal species were the vervet monkey *Cercophithecus pygerythrus*, bushveld tree squirrel *Paraxerus cepapi* and scrub hare *Lepus saxatilis*. Among rodents and small insectivores, *Tatera* species were recorded together with the tree mouse *Thallomys paedulcus* and rock elephant shrew *Elephantus myurus* (Macdonald 1990).

Birds. During the field survey in January 1989 a total of 120 species were recorded. "The actual number of species present is likely to be considerably higher than this. The majority of species are small insectivores (53%), with seed eaters (11%), mixed feeders (8%), water birds (11%) and raptors including owls (9%) comprising most of the remainder. The relatively large number of species of water birds in this semi-arid region is due to the presence of permanent pools of water on the Motloutse river downstream from its confluence with the Letlhakane river. - Most of the species recorded are typical of the region as a whole, though there were some interesting records" (MacDonald 1990).

Reptiles and amphibians. Reptiles and amphibians were recorded during a two-day period of field work (July 1993) at four localities, representing major habitats, in the proposed reservoir area. A total of 14 lizards, 2 snakes and 4 tortoises were observed. General knowledge, however, suggests that the number may be expected to be considerably higher (Cave 1994).

2.3.3 Aquatic fauna

Previous studies on water quality, distribution of fish species, rare and endangered aquatic organisms and other hydrological data have been reviewed (Cave 1994). Moreover, fish samples were taken at ten localities in and near the dam site in the Motloutse River and its tributaries in January 1993. A 2-day survey of fish in the existing Shashe Dam and in pools below the dam was also made, since the planned Letsibogo

Dam can be expected to develop a similar fish community to that in the Sashe Dam (Cave 1994).

At present, the Motloutse River harbours a temporary fish community consisting of five or more regular, pioneer fish species that migrate upstream from the Limpopo River into the Motloutse River during normal floods. These are the threespot barb *Barbus trimaculatus*, straightfin barb *Barbus paludinosus*, rednose labeo *Labeo labeo*, sharptooth catfish *Clarias gariepinus* and Mocambique tilapia *Oreochromis mossambicus* (Cave 1994). However, some other species may also enter the Motloutse during prolonged flooding and species collected in the Limpopo River have been listed in the report (Cave 1994).

2.3.4 Hydrology

During the rainy season, the river floods for shorter or longer periods flushing out accumulations of pollutants and salts resulting from evaporation of water. The flood waters are slightly acid to neutral with a lower conductivity than the normal river water, but with bicarbonates of Mg or Ca still being dominant. The Motloutse River, however, rises in and flows through an area in which the soils are base-saturated and, in lower lying areas, frequently calcareous. The natural waters are therefore neutral to slightly alkaline (Cave 1994).

Effluent very high in sulphates and chlorines, particularly deriving from the Bamangwato Concession Limited (BCL) mine and the Selebi-Phikwe treatment plant, flows into the Lethlakane and then into the Motloutse. However, by the time it reaches the Lethlakane it is no longer acidic, having picked up Na, Ca and K from the substrate and other polluters and been diluted. It is nevertheless still saline. The *Escherichia coli* count in the waters discharged into the Lethlakane River from the town sewage plant is far beyond acceptable levels (Cave 1994). Thus, the dilution of the effluent by the flow of the Motloutse is a crucial point that has been addressed.

Water samples were taken and analysed from 15 points in the Motloutse and the Lethlakane rivers in May 1993, and the results have been compared with water analyses supplied by the BCL mine and analyses of water obtained during earlier trips to the area (Cave 1994).

2.3.5 Other aspects

Several other aspects regarding the cultural environment have been considered, i.e. archaeology, existing land use, population status of the area, socio-economic issues, recreation/tourism potential, visual/aesthetic aspects, land tenure, infrastructure, industry/mining and current pollution status (Cave 1994).

2.4 Evaluation of the study and the extent of documentation

The environmental studies carried out in connection with the reservoir comply with the standards called for by NORAD (1990) and resemble studies normally undertaken in connection with the construction of a reservoir. As was the case with the zoological studies relating to the pipeline, the extent of the field work on birds and mammals, and the methods used, could have been more accurately documented. More extensive monitoring of the movements of large mammals and their exploitation of the area would also have been beneficial, for instance in connection with future plans for developing tourism. Moreover, legislation regarding future land use could have been addressed, together with an evaluation of effects on groundwater recharge in downstream areas. However, in general, the topics addressed in the EIA cover the majority of the issues that can logically be expected to be included in an EIA.

3 Environmental impacts identified

3.1 The pipeline

During the NSCWP Donors Conference in Botswana in June 1994, Paul Larkin stated that "no major social disruptions are envisaged", that "archaeological sites will be protected as necessary" and that "the impact on flora and fauna won't be significant" (WUC 1994b). In the final report (Larkin 1994), it is ascertained that "no major issues have been identified that would require abandonment of the approach or major changes to the design" of the project.

3.1.1 Vegetation and wildlife

The construction of the pipeline will involve the clearing of all vegetation over the working width (in general about 50 m), excavation and backfilling of the trench. This may lead to the promotion of soil erosion and compaction of soils, with consequent loss of productivity of arable land (Larkin 1994).

However, the overall conclusion made by Environmental Consultants is that "no significant impacts are anticipated due to the biogeographical uniformity of eastern Botswana and the extensive field survey of vegetation and wildlife habitats. - The construction of the North-South Carrier will be a very positive impact with regard to obtaining more data on the distribution of smaller animals" (Larkin 1994). The last statement is supported by the supposition that the excavated pipeline trench will act as a continuous linear sampling transect for several taxa of smaller animals.

During the appraisal mission on November 23, Paul Larkin reiterated what he stated in June that the negative environmental impacts are not significant and that the planning work on the pipeline should proceed.

3.1.2 Other aspects

Other topics addressed are impacts on archaeological sites and issues of socio-economic relevance. However, these are properly dealt with and outside the scope of the present report.

3.2 The Letsibogo Dam

The final report (Cave 1994) summarises the impacts under the following headings:

(a) impact on reptiles
(b) impact on downstream water quality due to curtailment of flow
(c) impact on water quality due to vegetation decomposition
(d) impact on the aquatic ecosystem
(e) impact on archaeology
(f) impact on the social environment
(g) impact on health
(h) impact on pollution
(i) impact on sand extraction operations
(j) visual impacts

Impacts regarding vegetation and zoological aspects (except reptiles) are considerd in detail by MacDonald (1990).

3.2.1 Vegetation

MacDonald (1990) gives the following assessment: "The apparent absence in the reservoir area of any endangered, vulnerable or rare taxa as identified in the field surveys does not imply that the conservation status of the plants occurring there is necessarily secure. First, the project area is little known or collected botanically. Second, by definition, rare plants are unlikely to be found easily, particularly in a two-week survey. One species, *Rhinacanthus gracilis*, was collected for only the second time in Botswana (the first specimen having been collected during the Lower Shashe Dam survey). Third, the threats posed to a species' survival are also not simply an inverse function of its population size. The extent of a species' geographic range and its degree of habitat specialisation also influence its vulnerability to disturbance or habitat destruction. Thus, species confined to the banks of the larger rivers are vulnerable to changes in river flow regime irrespective of their abundance".

3.2.2 Terrestrial zoological aspects

Birds. MacDonald (1990) gives the following assessment of the avifaunal findings: "Some of the bird species recorded during the survey are considered to be vulnerable or rare in South Africa. These include *Ephippiorhynchus senegalensis, Marabou leptoptilos crumeniferus*, lappetfaced vulture *Torgos tracheliotus* and bataleur *Terathopius ecaudatus*. The population size of the saddlebill stork is estimated to be less than 50 pairs in South Africa, and the species is probably rare in southern and eastern Botswana. The species is reported to have bred in riverine woodland along the Motloutse river in recent years. The sighting of a young bird there during the survey supports this. - The species requires reasonably large stands of mature, undisturbed riverine woodland for successful nesting. The impact of building a dam at Letsibogo would depend on whether there was a die-back of the riverine woodlands caused by a reduction in downstream river flow. On the positive side, the formation of a large reservoir could benefit the species by providing more foraging habitat for the storks. Another species, the boulder chat *Pinarornis plumosus*, endemic to the granite shield of Zimbabwe and Botswana, is confined to rocky hills and outcrops and was found on a number of these within the proposed reservoir. Construction of a dam would result in a loss of habitat for a number of pairs

occupying the outcrops which lie on the proposed line of the dam wall. Nevertheless, the species occurs on other outcrops in the area and the construction of the dam would not appear to threaten seriously the conservation status of this species".

Mammals. MacDonald (1990) gives the following assessment: "Under present land use, the prospects for wildlife in the project area are limited. The general trend over the past decades or longer has been one of a gradual decline in the numbers and diversity of the larger mammals as human livestock populations have increased. The trend seems likely to continue. The causes for this are complex and include competition with livestock for food, water and space; habitat modification; and hunting disturbance by people".

Reptiles, amphibians. No serious negative impact on the reptile fauna is expected, as only a small number of hills will be completely inundated during construction. Unique assemblages or rare species were not recorded during the field work (Cave 1994).

3.2.3 Aquatic zoological aspects

The dam will be a permanent barrier to migrating fish from the Limpopo, and it is unlikely that fish from the reservoir will survive downstream migration over the dam wall if special precautions are not taken. Thus, the net effect on the fish communities in the river below the dam will be negative. The subsurface flow of water in the river bed must be stabilised by special release of water if fish buried in the sand river are to survive (Cave 1994).

3.2.4 Hydrology

The impact on water quality downstream from the dam will be significant because of curtailment of flow and the dam reducing the capacity of the river to absorb pollutants. It is particularly underlined (Cave 1994) that the achievement of acceptable water quality in the Motloutse River downstream from the BCL mining complex depends on a reliable base flow of good quality water and control of pollutants. Such a base flow will be interrupted by the Letsibogo Dam; thus, the discharge of pollutants will have to be controlled. If effluent discharge downstream from the Lethlakane River cannot be reduced then the compensation flow from the Letsibogo Dam will have to be considerably increased to provide sufficient dilution.

In the reservoir, impact on water quality due to vegetation decomposition could be a significant problem. However, the seriousness of this impact depends on several factors and it is difficult to predict short-term and long-term developments. The initial nutrient levels may generate H_2S (hydrogen sulphide) production due to, for instance, blue-green algae and bacterial activity under anaerobic conditions. Eutrophication and anaerobic conditions may also be promoted due to supply of P and N from external sources (e.g. defaecating animals) in the proximity of the reservoir and in upstream areas.

The reservoir may develop thermoclines in the water body. However, this is difficult to predict and depends greatly on external factors (e.g. wind and temperature).

3.2.5 Other aspects

Other topics being addressed are visual impacts, impact on sand extraction operations, archaeology, the social environment and health. These are properly dealt with, but are outside the scope of the present report. However, water-borne diseases are of zoological relevance.

Bilharzia (schistosomiasis) is, at the moment, not a problem in the area, and only a couple of cases are treated each year. However, experts consulted (Cave 1994) confirm that a very real danger exists for an increasing incidence of bilharzia in Botswana where new impoundments of water are established. The vector snails prefer flat, shallow water, and vegetation around water bodies and irrigation canals forms their main habitat. It is considered certain that the snails will become established in the Letsibogo Dam sooner or later (Cave 1994).

The disease is caused by a flatworm (blood fluke) of the genera *Schistosoma* (Trematoda), *S. haematobium* causing urinary schistosomiasis and *S. mansoni* causing the intestinal form. In Zimbabwe, as many as 80% of children are found to be infected (Woolhouse 1987) and the medical authorities in various African countries regularly confirm that many children between 2 and 14 years frequently are infected by schistosomiass. This is because children in this age group commonly play and bathe in small ponds where they become infected.

The life cycle for the schistosome parasite includes a secondary host - a freshwater snail - of different species throughout the world. Schistosome larvae (miracidia) hatch from eggs which people have excreted directly or indirectly into the water in either urine or faeces. These larvae infect the snail. Later, another larval stage (cercariae) emerges into the water from the snail and in this stage the schistosome parasite is able to bore through the human skin and enter the blood vessels, mate and produce spined eggs. The swimming cercariae are primarily dangerous in small ponds.

The schistosomiasis problem should not be underestimated since a high percentage of the population is less than 15 years old. Many teachers believe that children with schistosomiasis do less well at school (Woolhouse 1987).

Malaria is recorded each year during the wet season and deaths have occurred. It is, however, stressed that the mosquito populations of Botswana have been very poorly studied and that little is known about the vector species and concentrations. "There is a definite lack of scientific data needed for malaria research to be done in Botswana" (Cave 1994).

4 Recommendations and management actions

4.1 The pipeline

The impacts of construction on the land surface will be mitigated by (i) careful control of the removal of vegetation across the working width, (ii) stripping and separate stockpiling of the topsoil prior to trenching, and (iii) replacement of soil layers in their original order immediately after pipelaying. The philosophy regarding land acquisition has been that areas directly affected during the construction phase should be reverted to agricultural and grazing use, and permanent installations should be prohibited (Larkin 1994).

It is stressed that in areas prone to soil erosion, vegetation should be cleared as closely as possible in time to the trenching and pipelaying operation. Moreover, during trenching, the subsoil should be stockpiled separately. Scrub cleared from the working width would be placed over the stockpiles to prevent wind and rain erosion. The seed bank in the topsoil is expected to be sufficient to secure regrowth, together with the cleared scrub preserved on the stockpiles; however, irrigation will be a prerequisite for achieving success. Contour grading will be employed to avoid creating a runoff channel along the pipeline route (Larkin 1994).

Although Environmental Consultants state in their report that the excavated trench will act as a pitfall trap for several animal taxa, this is not regarded as a hazard to wildlife and no mitigating measures are proposed in connection with this. The open trench is actually looked upon as having a positive effect in the sense that it will enable field zoologists and taxonomists to make collections.

Larkin (1994) has proposed that a monitoring programme should be carried out during construction of the pipeline and that post-construction monitoring should also take place. The main objective of the environmental supervision will be "to ensure that as far as possible the necessary actions for acquiring unencumbered access to land for the project are taken in good time; to minimize any delays to the contractors due to unpredictable events such as difficulties in gaining access to land, the discovery of previously unknown archaeological sites, etc.; to ensure that all environmental provisions and recommendations arising from the ongoing environmental impact assessment are adhered to and to provide training to the PCU staff" (Larkin 1994).

The main environmental post-construction monitoring will be to periodically inspect the pipeline and access roads to ensure that soil erosion control measures are effective and to take action where they are not (Larkin 1994).

4.2 Evaluation of proposed actions

The main concern regarding the pipeline construction is related to erosion problems due to slow revegetation. Arid and semi-arid ecosystems are in general vulnerable to heavy human influence. Theoretically, the actions proposed for preventing erosion along the pipeline route should be adequate. Most of the pipeline will be adjacent to the existing main road. When areas along newly constructed roads are looked at, it seems impossible to find specific areas where revegetation has not taken place. Moreover, the pipeline will to a major extent pass through flat terrain; thus, it is unlikely that surface runoff during heavy rain will be an erosion hazard. However, it seems important that the environmental team proposed for the monitoring programme should include a biologist, preferably a botanist, to follow up regrowth on those areas affected by the pipeline project.

A monitoring programme should also take into consideration the future increase in effluents from city areas, in particular the Gaborone area. It seems clear that a post-construction monitoring programme should be viewed in the context of the proposed reorganisation of the present split responsibility between MLGL&H and MMRWA and the prospects for the Gaborone Sewerage Masterplan Studies.

During the construction period, a large open trench will remain a threat to various animal species for some time. Details on the estimated duration of an open trench have not been available. However, the trench will be temporarily fenced in during this period (P. Larkin, pers. comm.). Nevertheless, this hazard should not be underestimated and regular inspections should be carried out. From an objective point of view, I disagree with Environmental Consultants that the trench has a positive effect in the sense that it may contribute to increased taxonomic knowledge of certain animal groups. Such a consideration is outside the scope of an EIA.

4.3 The Letsibogo Dam

The establishment of a reservoir in a tropical environment is always a reckless experiment from an ecological point of view. Thus, several precautions normally have to be taken. The recommendations and management actions proposed by Cave (1994) consequently cover a wide range of subjects.

As regards **the terrestrial ecosystem,** little can normally be done beyond documenting the existing floral and faunal elements and hoping that the surrounding area will suffice to provide for the survival of the "homeless" individuals. The inundation process will nevertheless "exterminate" all terrestrial life. In the present situation, however, an operation to rescue reptiles from rocky outcrops has been proposed (Cave 1994).

With respect to **the aquatic ecosystems**, existing ones will be either destroyed or greatly altered. However, a new ecosystem (the reservoir) will be created, giving several new management options as well as opportunities for a new fauna and flora to establish, some of the species being appreciated while others will be regarded as pests. Although it is stressed (Cave 1994) that weeds, i.e. macrophytic vegetation species like *Salvinia molesta, Pistia stratoides* and *Eichornia crassipes,* should not be introduced into the reservoir, earlier experience from numerous dam projects shows that this is theoretically desirable, but more or less unavoidable in practice.

Regarding the inundated area, Cave (1994) states that "it is unnecessary to remove plant matter from the reservoir area, as the amount of P released into the dam is likely to be small. Instead, the release of nutrient-enriched water from the initial flooding of the reservoir is recommended".

Hopefully, the proposed release from the dam will maintain the permanent pools of water in the Motloutse River downstream from its confluence with the Lethlakane and thus the habitats of waterbirds (cf. MacDonald 1990).

The reservoir is predicted to overtop the spillway once in five years, which is insufficient to maintain the present migrating pattern of fish from the Limpopo. The cost of ensuring this is, however, considerd "out of proportion to the migration frequency of fish" (Cave 1994). Instead, it is recommended that fish congregating at the dam base during periods of major water release from the dam are caught and released into the reservoir.

The Letsibogo Dam can be used for aquaculture purposes, and it is proposed to introduce several fish species into the reservoir. However, it is very difficult to achieve a desired fish species composition and a more or less stable aquatic ecosystem. It is stressed that a fisheries biologist should supervise this operation constantly to ensure that no exotic, unwanted species are introduced (Cave 1994). A follow-up monitoring programme for the aquaculture project is proposed, to focus on (i) fish species present in the dam after initial filling starts, (ii) the fish community structure after stocking with recommended species to establish colonising and breeding success, (iii) fish growth rates and population size or density to determine cropping rate and specifications of gill netting licences to be issued to prospective fishermen, (iv) catch per unit effort of the commercial fishery on a seasonal basis, (v) price structure of fish marketing activities in the area surrounding the dam (Cave 1994).

A **health** service monitoring programme is proposed to obtain detailed information on future evolvement of such diseases as malaria and bilharzia.

Because of reduced flow in the downstream areas, pollution is a particularly important issue to be addressed. It is proposed (Cave 1994) that the Department of Water Affairs (DWA) should obtain the cooperation of all polluters in reducing their pollutant contributions to the minimum. If, as currently proposed, there is an annual release of 1.3 Mm^3 of water from the dam as compensation flow, the combined effluent dis-

charge into the Lethlakane River must be decreased to 0.8 Mm^3 per annum. If this discharge cannot be reduced, at least 6.72 Mm^3 per annum of impounded water would have to pass the dam to provide sufficient dilution. This is approximately 28% of the dam yield (of 24.1 Mm^3 per annum) (Cave 1994).

An environmental/biophysical monitoring programme is proposed, to serve as an environmental watchdog. Monitoring of the water quality in the reservoir should take place regularly, and monitoring of sand-stored water should take place upstream and downstream from the reservoir. It is also strongly recommended that a reliable model is prepared to compute the quantities and timing of water releases from the Letsibogo Dam and their effect on water quality in the Motloutse River (Cave 1994).

4.4 Evaluation of proposed actions

The proposed mitigating measures and the recommendations for management actions are in agreement with current ecological knowledge. However, it must be stressed that they do not provide a guarantee that future problems will be avoided.

It is particularly satisfying to note that the Letsibogo Dam EIA has discussed the need for a broad range of monitoring and follow-up studies in connection with the project. It is crucial that these take place. It is particularly important that the water quality in the reservoir is monitored since eutrophication through decomposition of vegetation may be expected, and that aspects of hydrology and pollution as well as the riverine ecosystems in downstream areas are monitored. The BCL mine with its Cu and Ni production causes a particular pollution threat. Even fractures in sedimentation ponds must be expected to take place, with substantial loss of pollutants.

I am more doubtful than the consultant about the positive effects of leaving vegetation in the reservoir. All organic matter left in a reservoir, particularly in a tropical or subtropical climate, will contribute to eutrophication. A shallow lake, like the Letsibogo Dam inevitably will be, has a huge potential for organic production under the existing climatic conditions. There are sound arguments against as well as for leaving trees in the reservoir, and the most important ones are mentioned in the report (Cave 1994). Experience from, for instance, Norway is that when trees and other forms of higher vegetation are left they frequently create serious problems for net fishing and a hazard to boat traffic. From an aesthetical point of view it is not to be recommended that trees are left in a reservoir. When trees are removed, their roots and stumps will remain and will stabilise the soil against prevailing winds and wave action. However, this will only give temporary protection. On the other hand, the niche-creating effect, particularly for fish, is important.

Rescue operations (in this case for reptiles) are always debatable since it is a very open question whether surrounding areas are able to provide enough resources for more animals than they already contain, i.e. there may be no empty niches for new individuals. Thus, this is more a question of ethics.

The present legislation should be addressed to adopt laws, regulations and policies for the protection and management of the reservoir environment, and to enforce such laws as may be required. This is also important for assessing and monitoring the risks and environmental effects of pollution, or any other relevant environmental impact.

Finally, it is essential that the costs of the proposed actions, particularly the monitoring programmes, are considered now in connection with the final cost estimates.

5 Concluding remarks

The NSCWP is a giant project which will create predicted as well as unpredicted environmental problems. However, no satisfactory alternatives have so far been found for providing the southern population centres of Botswana with an adequate future water supply. Thus, deciding whether to agree to the proposed project or not in the end amounts to a question of assessing the number of environmental and political (economic) compromises that can be made. It is also debatable whether the assumptions regarding future population growth and water needs are correct. National and international economy, as well as factors like the spread of AIDS, are issues that must be addressed. However, demographic and socio-economic considerations are outside the scope of the present report. So also are technical aspects regarding silting up of the dam and prospects for filling the dam. Unforeseen drought and water loss through evaporation may create problems in achieving the anticipated level of water storage. In the end, these concerns are a matter of statistics, which hopefully are properly estimated by the technical planners. Hopefully, too, the ability of groundwater resources downstream from the dam to become recharged has been adequately considered.

Compared with current EIA practices in the Nordic countries, the environmental consultants have been responsible for a broad range of topics. Hence, subconsultants have been used. This may be a practical arrangement. However, it is important that the various subconsultants submit separate reports containing the basic data, such as detailed descriptions of methodology, thus enabling colleagues in the international scientific community to verify the findings. A cardinal rule within all science is that data should be able to be re-examined. No doubt should be left about which scientists have had responsibility for what topics. It should be made clear that all basic information collected is available on request. These aspects are excellently covered in the Letsibogo Dam Final Report. In the pipeline EIA it has so far been difficult to identify which experts have been responsible for the different aspects, i.e. botany, zoology, archaeology, health and socio-economics. It would have been advantageous if separate, detailed reports for all these fields had been prepared and made available. It should, however, be stressed that the final EIA report for the pipeline study has not been available, since it will not be finished before mid-December.

As expected, due to the different nature of the two encroachments, the design of the two studies differs. However, they also seem to differ in their philosophy in aspects where equal contribution could have been expected, e.g. field efforts regarding mapping of zoological taxa.

The project is a typical example of the need for international standards for EIA studies to determine the qualitative and quantitative criteria that need to be upheld in such scientific investigations. For instance, to what extent should field work be carried out and what methods should be used in connection with different types of encroachment and zoological taxa. Vegetation mapping is standard - e.g. at association level. Although there is increased focus on environmental issues and awareness of potential problems that can arise when an encroachment is made, environmental consultants have to compete for the projects, which naturally may affect the EIA quality. Thus, a key word is quality securement.

In general, I agree with the evaluations made by Environmental Consultants that the impacts of the pipeline construction lie within fair margins regarding environmental damage. In particular, I find the EIA study for the Letsibogo Dam satisfactory. This study has dealt with the majority of the environment-related aspects in an outstanding way, and the ecological analyses performed are, from a scientific point of view, profound. Actually, the study could form a model for equivalent future projects.

With background in the available documentation and talks with Alan Cave and Paul Larkin, my personal impression is that archaeological and socio-economic issues, etc. are also properly dealt with.

To the best of my knowledge, although I do not possess specific competence on climatic issues, the Letsibogo Dam and the transfer of water to the Gaborone district will not affect local or regional climates significantly. The large-scale geophysical conditions in the region make the scale of the present encroachment more or less insignificant. However, it must be stressed that this view is based upon a general understanding and not on specific competence.

6 Summary

In Botswana, most economic activity and population growth is occurring in the southern and eastern districts, and the Gaborone area has a particularly high growth rate with a correspondingly increasing need for water. Because of this, a plan for a transfer water system has been developed, known as the North-South Carrier Water Project (NSCWP). There are two major environmental encroachments and artificial constructions connected with the NSCWP: (i) the building of a reservoir on the Motloutse River (Letsibogo Dam) and (ii) the building of a water transfer pipeline. NORAD, together with the Nordic Development Fund (NDF), the Nordic Investment Bank (NIB) and the Swedish Board for Investment and Technical Support (BITS), are considering providing financial support to the NSCWP. However, these organisations have been concerned about the possible environmental consequences of the proposed project and wanted a review of existing information on the environmental impact assessments that have been made in the context of the project.

In addition to the general environmental aspects connected with water supply demands in Botswana, dealt with in a National Water Masterplan (NWMP) study, specific environmental aspects regarding the Letsibogo Dam and the transfer pipeline have been considered by Cave Klapwijk and Associates, and Environmental Consultants, respectively.

The transfer pipeline will be about 360 km long and will transfer water from the proposed Letsibogo Dam to a southern treatment works and Master Balancing Reservoir (MBR), approximately 15 km north-east of Gaborone. The pipeline will be placed in the ground and the water flow has been estimated to reach 15.9 million m^3 per year in 1999. The pipeline will to a great extent be located close to, and within the reserves of, the existing main road and railway, within an area characterised by a "fairly high degree of topographic, geological, pedological and biogeographical uniformity". Vegetation mapping has been carried out along the whole pipeline route and vegetation types at association level have been identified and described. Mammals, birds, reptiles and amphibians have been considered as faunistical elements. Insects and the microfauna have not been subject to any analyses. The conservation status of each species has been considered.

In general, the environmental studies carried out in connection with the pipeline seem to comply with the standards called for by, among others, NORAD. However, the documentation so far available makes it difficult to judge the effort made in the field. Expressions like "potentially" existing species are frequently used, indicating that the knowledge is based on general zoogeographical information from the literature. It should be pointed out that this type of information should not be considered sufficient when an EIA is being made on a specific local encroachment. Overall, the impression remains that, despite considerable effort, more systematic, comprehensive field work should have been carried out on the zoological part of the study, using standardised methods for qualitative and quantitative mapping of the occurrence of species in the area. In particular, efforts should have been made to identify reptiles and amphibians.

Clearance of all vegetation across the working width (in general about 50 m), excavation and backfilling of the pipe trench, will take place. This could lead to promotion of soil erosion and compaction of soils, with consequent loss of productivity of arable land. However, the overall conclusion drawn by Environmental Consultants is that "no significant impacts are anticipated due to the biogeographical uniformity of eastern Botswana and the extensive field survey of vegetation and wildlife habitats. - The construction of the North-South Carrier will be a very positive impact with regard to obtaining more data on the distribution of smaller animals". This last statement is supported by the assumption that the excavated pipeline trench will act as a continuous linear sampling transect for several taxa of smaller animals. Details on the estimated duration of an open trench have not been available, but the trench will be temporarily fenced in during the open period. Nevertheless, this hazard should not be underestimated, and inspections should be carried out regularly. From an objective point of view, I disagree with Environmental Consultants that the trench has a positive effect in the sense that it may contribute to increased taxonomic knowledge of certain animal groups. Such a consideration is outside the scope of an EIA.

The impacts of the construction on the land surface will be mitigated by (i) careful control of the removal of vegetation across the working width, (ii) stripping and separate stockpiling of the topsoil prior to trenching, and (iii) replacement of soil layers in their correct order immediately after the pipelaying takes place. It is stressed that in areas prone to soil erosion, vegetation clearance should take place as closely as possible in time to the trenching and pipelaying operation. Together with the cleared scrub preserved on top of the stockpiles, the seed bank in the topsoil is expected to be sufficient to ensure regrowth, but irrigation will be a prerequisite for success in the restoration work. Contour grading will be employed to avoid creating a runoff channel along the pipeline route.

Theoretically, the proposed actions to prevent erosion along the pipeline route should be sufficient. Revegetation along newly constructed roads seems to be good. Moreover, since the pipeline will largely pass through flat terrain, it is unlikely that surface runoff during heavy rain will be an erosion hazard.

It is proposed that monitoring programmes should take place during and after the construction of the pipeline. It seems important for the environmental team proposed for the monitoring programmes to include a biologist, preferably a botanist, to follow up regrowth on the areas affected by the pipeline project. The monitoring programme should take into consideration the future increase of effluents from city areas, in particular the Gaborone area. A post-construction monitoring programme should also be viewed in connection with the

proposed reorganisation of the present divided responsibility between MLGL&H and MMRWA and the prospects for the Gaborone Sewerage Masterplan Studies.

The study has dealt with land acquisition and socio-economic aspects in commendable detail, likewise archaeology. The philosophy regarding land acquisition has been that the areas directly affected during the construction phase should revert to agricultural and grazing use, and that permanent installations should be prohibited.

The Letsibogo Dam is planned as a 28 m high rock-filled dam and will provide active storage of 100 Mm^3 of water, the reservoir having a drawdown of 13 m. At full supply level (848.8 m a.s.l.) the reservoir will cover an area of 18 km^2, but under a flood situation it could cover 21.66 km^2. The dam wall is expected to be located approximately 3 km upstream from the village of Mmadinare, about 70 km south of Francistown.

The Motloutse is an ephemeral sand river, i.e. surface flow only occurs during the rainy season. However, a low subsurface flow (at a mean of 6 l/sec.) continues throughout the rest of the year.

According to his TOR, the consultant was expected to review the feasibility and preliminary design studies made in 1989 of the vegetation and fauna/wildlife. This review indicated that the impact on vegetation and fauna (except reptiles) "was considered in sufficient depth to make final conclusions on the mitigation of impacts on these aspects". A vegetation map for the reservoir area was prepared and was included in the feasibility study report. The vegetation of the project area is termed as Mixed Mopane/Acacia Tree Savanna, and the dominant tree species of this regional vegetation formation is *Colophospermum mopane*.

During the rainy season, the rivers flood for shorter or longer periods flushing out accumulations of pollutants and salts resulting from the evaporation of water. The natural waters are neutral to slightly alkaline. Effluent very high in sulphates and chlorines, particularly arising from the mine belonging to the Bamangwato Concession Limited (BCL) and from the Selebi-Phikwe treatment plant, flows into Lethlakane River and then into the Motloutse. Thus, the dilution of the effluent by the flow of the Motloutse is a crucial point that has been addressed.

Several other aspects regarding the cultural environment have been considered, i.e. archaeology, existing land use, population status of the area, socio-economic issues, recreation/tourism potential, visual/aesthetic aspects, land tenure, infrastructure, industry/mining and current pollution status.

The environmental studies carried out in connection with the reservoir comply with the standards called for by NORAD, and are comparable with the extent of studies normally undertaken in connection with this type of reservoir. As was the case with the zoological studies relating to the pipeline, the extent of the field work dealing with birds and mammals, and the methods used, could have been more accurately documented. More extensive monitoring of the movements of large mammals and of their exploitation of the area would also have been beneficial, for instance in connection with future plans for the development of tourism. Moreover, legislation regarding future land use could have been addressed. However, in general, the topics addressed in the EIA cover the majority of those issues that can logically be expected to be included in an EIA.

The proposed mitigating measures and the recommendations for management actions are in agreement with current ecological knowledge. Although they do not guarantee that future problems will be avoided, if followed carefully, the negative environmental effects of the project are expected to be minimised to a tolerable level.

It is particularly satisfying to note that the Letsibogo Dam EIA has discussed the need for a broad range of monitoring and follow-up studies in connection with the project. It is crucial that these are put into practice. It is particularly important that the water quality in the reservoir is monitored, as eutrophication due to vegetation decomposition may be expected, and that hydrological and pollution aspects, as well as the riverine ecosystems in downstream areas, are monitored. The BCL mine with its Cu and Ni production causes a particular pollution threat.

The NSCWP is a giant project which will create predicted as well as unpredicted environmental problems. However, no satisfactory alternatives have so far been identified for providing the southern population centres of Botswana with adequate, future water supply. Thus, the decision whether to agree to the proposed project or not is, in the end, a question of the number of environmental and political (economic) compromises that can be made. It is also debatable whether the assumptions regarding future population growth and water demands are correct. The national and international economy, as well as factors like the spread of AIDS, are issues that must be addressed. However, demographic and socio-economic considerations are outside the scope of the present report. So, too, are technical aspects regarding silting up of the dam and prospects for filling it. Unforeseen drought and water loss through evaporation may create problems in achieving the water storage anticipated. In the end, these concerns are a matter of statistics, which hopefully have been properly estimated by the technical planners. Hopefully, too, the impact on the recharge ability of the groundwater resources downstream from the dam have been adequately considered.

The project is a typical example of the need for international standards for EIA studies to determine the qualitative and quantitative criteria that need to be upheld in such scientific investigations. For instance, to what extent should field work be carried out and what methods should be used in connection with different types of encroachment and zoological taxa. Vegetation mapping is standard - e.g. at association level. Although increased focus is being put on environmental

issues and awareness of potential problems that can arise when an encroachment takes place, environmental consultants have to compete for the projects, which naturally may affect the quality of the EIA. Thus, a key word is quality securement.

With background in the available documentation and talks with Alan Cave and Paul Larkin, my personal impression is that archaeological and socio-economic issues, etc. have also been properly dealt with.

In general I agree with the evaluations made by Environmental Consultants that the impacts of the pipeline construction lie within fair margins regarding environmental damage. In particular, I find the EIA study for the Letsibogo Dam satisfactory. The study has dealt with the majority of environment-related aspects in an outstanding way, and the ecological analyses performed are, from a scientific point of view, profound. Actually, the study could form a model for equivalent future projects. However, it is critical that the costs of the proposed actions, particularly the monitoring programmes, are considered at the present stage in connection with the final cost estimates.

To the best of my knowledge, although I do not possess specific competence on climatic issues, the Letsibogo Dam and the transfer of water to the Gaborone district will not affect local or regional climates significantly. The large-scale geophysical conditions in the region make the scale of the present encroachment more or less insignificant. However, it must be stressed that this view is based upon a general understanding and not on specific competence.

7 Sammendrag

En vesentlig del av økonomisk og befolkningsmessig vekst i Botswana er knyttet til de sørlige og østlige distriktene av landet. Gaborone-området har en spesielt høy vekstrate med tilsvarende økte behov for vann. På grunn av dette er det utviklet en plan for overføring av vann, kjent som "The North-South Carrier Water Project (NSCWP)" fra de sørøstlige områdene nær Francistown til Gaboroneområdet. De to største naturinngrepene i tilknytning til prosjektet består i bygging av et vannreservoar (Letsibogodammen) og bygging av en vannrørledning. NORAD, sammen med det nordiske utviklingsfondet (NDF) og den nordiske investeringsbanken (NIB) og BITS (Swedish Board for Investment and Technical Support), vurderer å bidra som finansieringskilder til prosjektet. Disse institusjonene har imidlertid vært bekymret over mulige negative miljøkonsekvenser som prosjektet kan medføre og ønsket derfor en frittstående evaluering av de miljøundersøkelsene som har vært foretatt i tilknytning til prosjektet.

Vannrørledningen vil bli ca 360 km lang og skal føre vann fra Letsibogodammen til et renseanlegg og en inntaksdam ca 15 km nordøst for Gaborone. Rørledningen vil bli gravd ned i bakken og vannmengden som skal overføres er estimert til 15,9 millioner m^3 pr år i 1999. Rørledningen vil i stor utstrekning bli lokalisert langs, og delvis innenfor, de statseide landarealene til eksistrende hovedveier og jernbane, i et område med relativt stor grad av topografisk, geologisk, jordbunnsmessig og biogeografisk ensartethet. Hele rørledningstraséen er vegetasjonskartlagt, og vegetasjonsenheter på assosiasjonsnivå er identifisert og beskrevet. Pattedyr, fugler, krypdyr og amfibier er vektlagt ved den faunistiske undersøkelsen, mens insekter og mikrofauna ikke har vært undersøkt. Den enkelte arts vernestatus er vurdert.

Miljøkonsekvensanalysene som er utført i tilknytning til rørledningen og reservoaret er generelt i tråd med de standarder som bl.a. er indikert av NORAD. Det er imidlertid vanskelig ut fra tilgjengelig dokumentasjon å bedømme hvor stor feltinnsatsen har vært. Uttrykk som «potensielt forekommende arter» er ofte benyttet, hvilket indikerer at opplysningene er basert på generell zoogeografisk informasjon fra eksisterende litteratur. Det bør bemerkes at dette generelt ikke kan anses fullt ut tilstrekkelig når det er snakk om en EIA for å bedømme lokale naturinngrep. Undersøkelsen etterlater et inntrykk av, når det gjelder den zoologiske delen, at det til tross for en hederlig innsats burde vært utført et mer systematisk og omfattende feltarbeid, med større vektlegging på bruk av standardiserte metoder for kvantitativ og kvalitativ kartlegging av arters forekomst og utbredelse i de berørte områdene. Spesielt burde større innsats ha vært gjort for å få kartlagt amfibier og krypdyr.

All vegetasjon i arbeidsområdet der rørledningen skal graves ned vil bli fjernet; generelt en ca 50 m bred stripe. Det øverste jordlaget vil bli skjøvet vekk og siden lagt på igjen når rørledningen er på plass. Selve grøftearbeidet vil kunne føre til

en viss erosjonsfare og hardpakking av jordsmonnet med nedsatt produktivitet ved bruk av overflatearealene i jordbrukssammenheng. Environmental Consultants (EC) i Gaborone, som har vært ansvarlige for miljøstudiene i tilknytning til rørledningen konkluderer imidlertid med at på grunn av de omfattende undersøkelsene som er gjort både i forhold til vegetasjon og fauna og på grunn av den biogeografiske ensartetheten en finner i det østlige Botswana, antas prosjektet ikke å få signifikante negative følger for miljøet. Tvert imot mener EC at prosjektet har positive følger, bl.a. fordi zoologer vil ha mulighet til å øke sin taksonomiske kunnskap ved å studere og fange dyr som faller ned i grøfta mens denne står åpen. Detaljer omkring hvor lang tid selve grøfta vil stå åpen har ikke vært tilgjengelig, men det vil bli en temporær inngjerding i denne perioden. Det synes imidlertid ikke som problemer ved en åpen grøft av den dimensjon det her er snakk om bør undervurderes, heller ikke i forhold til større arter, og inspeksjoner bør foretas jevnlig. Objektivt sett er jeg uenig med EC i at en slik grøft kan sies å ha en positiv effekt i faunistisk sammenheng til tross for at den kan bidra til økt taksonomisk kunnskap gjennom å virke som en fangstinnretning. Slike vurderinger ligger utenom det som er hensikten med en EIA.

Skader i tilknytning til legging av rørledningen vil minimaliseres gjennom en nøye kontroll av at vegetasjonen fjernes på en skånsom måte over grøfta, at det øverste jordlaget fjernes og lagres for seg, og at jordlagene legges på plass i samme rekkefølge som de ble fjernet umiddelbart etter at rørledningen er lagt. Det påpekes også at i områder som er utsatt for erosjonsfare, skal vegetasjonen fjernes så tett opp til rørleggingsarbeidene som mulig. Frøbanken i jordsmonnet antas å være tilstrekkelig til å sikre revegetering sammen med at den vegetasjonen som fjernes sammen med det øverste jordlaget blir satt på plass på en skikkelig måte. Irrigasjon etter at anleggsarbeidene avsluttes anses imidlertid som nødvendig for å sikre et godt resultat. Kunstig anlagte konturer på toppen av grøfta vil også bli laget for å hindre at rørledningsgrøfta blir en avrenningskanal.

Teoretisk skulle de foreslåtte tiltak være tilstrekkelig til å hindre erosjon langs rørledningen. Revegeteringen langs nyanlagte veier i de samme områdene som rørledningen vil gå, synes f.eks. å være relativt god. Rørledningen vil dessuten primært gå gjennom flatt terreng, hvilket vil redusere faren for avrenning og erosjonsproblemer, selv i forbindelse med kraftige regnskyll.

Det er foreslått at et overvåkningsprogram iverksettes for å følge utviklingen både under selve anleggsfasen og etter at arbeidene er avsluttet. Det synes å være viktig at miljøteamet som skal arbeide med dette programmet har en biolog med, fortrinnsvis en botaniker, bl.a. for å følge utviklingen av vegetasjonen langs rørledningstraseen. Et slikt overvåkningsprogram bør også vurdere eventuelle konsekvenser av fremtidig økning i kloakkavrenning fra byområdene, særlig i Gaborone-området og se dette i sammenheng med den foreslåtte reorganisering og ansvarsfordeling mellom de lokale myndighetene MLGL&H og MMRWA (se s. 8) og de prospekter som Gaborone Sewerage Masterplan Studies skisserer.

Miljøstudiene i tilknytning til rørledningen har behandlet problemer i tilknytning til grunnervervelse og sosio-økonomiske aspekter på en overbevisende måte så vel som arkeologiske undersøkelser. Den filosofi som er lagt til grunn for grunnervervelse er at de arealer som blir direkte berørt under anleggsarbeidene i størst mulig utstrekning skal tilbakeføres til produktivt jordbruksareal etter at arbeidene avsluttes, men at områder i tilknytning til permanente installasjoner vil bli avsperret.

Letsibogodammen er planlagt som en 28 m høy jord- og steinfyllingsdam med en magasineringskapasitet på 100 Mm^3 og med en tappehøyde på maksimalt 13 m. Når dammen er full (848,8 m a.s.l.) vil reservoaret dekke et areal på 18 km^2, men på grunn av at damkronen vil ligge 856 m o.h. vil flomsituasjoner kunne medføre neddemte arealer på opptil 21.6 km^2. Selve dammen er planlagt lokalisert til et sted ca 3 km oppstrøms landsbyen Mmadinare, ca 70 km sør for Francistown.

Motloutse er ei såkalt sandelv, hvilket vil si at elveleiet er tørt men unntak av enkelte perioder i regntiden. Gjennom hele året opprettholdes imidlertid en viss vannstrøm nede i sandmassene (gjennomsnittlig ca 6 l/sek.)

En omfattende miljøkonsekvensanalyse er utført i tilknytning til damprosjektet. Ifølge TOR skulle det i forhold til flora og fauna (unntatt krypdyr), foretas en gjennomgang og evaluering av de preliminære miljøundersøkelsene som ble foretatt i tilknytning til prosjektet i 1989. Denne gjennomgangen resulterte i at fauna og vegetasjonsdelen ble ansett for å være tilstrekkelig grundig behandlet til at det kunne trekkes konklusjoner i forhold til eventuelle avhjelpende tiltak. Et vegetasjonskart for de arealer som blir neddemmet ble utarbeidet i forbindelse med forundersøkelsen i 1989 og den dominerende vegetasjonen er beskrevet som «Mixed Mopane/Acacia Tree Savanna». Det dominerende treslag i denne regionale vegetasjonstypen er mopane - *Colophospermum mopane*.

Gjennom regnperioden flommer Motloutse opp for lengre eller kortere perioder og skyller ut oppsamlinger av forurensinger og salter som dannes som resultat av den store fordampingen i området. Den naturlige vannkvaliteten har en pH som er nøytral til svakt alkalisk. Avrenninger med svært høye sulfat- og klorverdier, som spesielt stammer fra gruvedriften hos Bamangwato Concession Limited (BCL) og vannverket i Selebi-Phikwe, renner inn i Lethlakaneelva og videre inn i Motloutseelva. Fortynningen av disse avrenningene gjennom flommene i Motloutse er følgelig et særdeles viktig punkt som er blitt grundig behandlet i undersøkelsen

En rekke andre miljøaspekter av kulturell karakter i tilknytning til prosjektet er blitt grundig vurdert; f.eks. arkeologi, eksisterende landutnyttelse, demografiske forhold i utbyggingsområdet, sosio-økonomiske elementer, potensiale i forhold til rekreasjon og turisme, visuelle og estetiske aspekter, eien-

doms- og infrastruktur, industri og gruvedrift og forurensingsstatus.

De miljøundersøkelsene som er utført i tilknytning til damutbyggingen synes i store trekk å være i overensstemmelse med de krav og standarder som bl.a. er indikert av NORAD når det gjelder tilsvarende inngrepstyper. På samme måte som ved de zoologiske undersøkelsene utført i tilknytning til rørledningen, kunne pattedyr og fugleregistreringene vært bedre dokumentert med hensyn til feltarbeidets omfang og hvilke metoder som har vært benyttet. En mer omfattende kartlegging av bevegelsesmønster hos større pattedyr og deres utnyttelse av områdene, kunne med fordel ha vært foretatt, ikke minst sett i lys av de planer som eksisterer for fremtidig utnyttelse av området i turistøyemed. Eksisterende lovgiving for å kunne sette i verk og håndheve nødvendige tiltak for å unngå problemer med hensyn til bruk av magasinets nærområder, burde også vært vurdert. Generelt dekker imidlertid undersøkelsen de aspekter som en med rimelighet kan forvente skal dekkes av en EIA.

Miljøkonsekvensanalysene som er utført i tilknytning til rørledningen og reservoaret er generelt i tråd med de standarder som bl.a. er indikert av NORAD, og de foreslåtte avhjelpende tiltak er i tråd med eksisterende økologisk forståelse og kunnskap i forhold til denne type naturinngrep. Selv om tiltakene ikke representerer noen garanti for fremtidige miljøproblemer, antas de, hvis de blir fulgt opp nøye, å kunne redusere negative miljøkonsekevenser til et tolererbart nivå

Det er spesielt tilfredsstillende å konstatere at en rekke overvåkningstudier for å følge fremtidig utvikling i forhold til miljøet, er foreslått, både for selve reservoaret og nedstrøms dammen. Det er avgjørende at disse tiltakene følges opp og settes ut i livet. Ikke minst viktig er det at vannkvaliteten i magasinet følges nøye etter som eutrofiering blant annet på grunn av nedbryting av vegetasjon i magasinet kan forventes. Dessuten må hydrologiske forhold og forurensingsaspekter og økosystemene nedstrøms dammen, følges nøye. Gruvedrift (BCL) med utslipp av Cu, Ni og andre stoffer, representerer en særlig farlig forurensingskilde.

NSCWP er et gigantprosjekt (med en kostnadsramme på vel 4 milliarder NOK) som utvilsomt vil forårsake såvel forutsette som uforutsette miljøproblemer. Det har imidlertid så langt vært vanskelig å se hvilke alternativer som finnes i forhold til det å skulle gi de sørlige, tett befolkede områdene i Botswana, adekvat, fremtidig vannforsyning. Avgjørelsen om å godta eller forkaste de eksisterende planer er derfor til syvende og sist et spørsmål om hvilke miljømessige og politiske (økonomiske) kompromisser som kan godtas. Det er også et spørsmål om de fremsatte scenarier i forhold til befolkningsvekst og vannbehov er korrekt. Nasjonal og internasjonal økonomi ved siden av faktorer som AIDS kan her være elementer som ikke er enkle å vurdere i den sammenheng. Demografiske og sosioøkonomiske betraktninger ligger imidlertid utenfor rammen for det denne rapporten skal vurdere. Det gjør også tekniske aspekter i forhold til sedimenteringsproblemer i magasinet og mulighetene for å få fylt dammen. Uforutsette tørkeperioder og vanntap gjennom fordamping kan skape problemer i forhold til det å skulle «oppfylle» planlagt magasineringskapasitet. Til syvende og sist er dette beregninger som er basert på statistikk. Statistikk er imidlertid ikke alltid like velegnet hjelpemiddel i et miljø der uforutsette episoder som f.eks. lange tørkeperioder er mer regel enn unntak. Forhåpentligvis er også betydningen av flomperiodene i Motloutse vurdert i forhold den effekt de måtte ha på grunnvannsreservoarer nedstrøms dammen.

De miljøundersøkelsene som er foretatt i tilknytning til prosjektet viser imidlertid at det er behov for internasjonale standarder som kan definere faglige kvalitative og kvantitative kriterier for de konsekvensanalyser slike prosjekter krever, f.eks. i hvilket omfang feltarbeid skal utføres og hvilke metoder som bør benyttes i forhold til ulike zoologiske taxa og inngrepskategorier, på samme måte som vegetasjonskartlegging stort sett er blitt standard med nøyaktighet på assosiasjonsnivå. Til tross for at miljøspørsmål i økende grad fokuseres og faren for utilsiktede problemer i forbindelse med naturinngrep får økt oppmerksomhet, må likevel miljøkonsulentfirmaer konkurrerer om prosjekter, hvilket naturligvis kan gå ut over kvaliteten til en EIA. Det er derfor viktigere enn noen gang at kvalitetssikring kommer inn som en naturlig del av slike opplegg.

På bakgrunn av tilgjengelig dokumentasjon og samtaler med Alan Cave og Paul Larkin, som har vært ansvarlige for henholdsvis dam- og rørledningsundersøkelsene, så er mitt personlige inntrykk at også arkeologi, sosioøkonomiske aspekter osv. er tilfredsstillende behandlet.

Generelt er jeg enig med Environmental Consultants i at de negative konsekvenser rørledningsprosjektet måtte få for miljøet ligger innen akseptable toleransegrenser. Undersøkelsene som er foretatt i tilknytning til magasinet er også godt utført og de fleste miljøaspekter i tilknytning til et slikt magasin er tilfredsstillende belyst, og de økologiske analyser som er foretatt er fra et faglig synspunkt meget gode. Studien er på mange måter så god at den uten videre kan benyttes som modell ved tilsvarende prosjekter. Det er imidlertid avgjørende at utgiftene ved alle foreslåtte tiltak, særlig overvåkningsprogrammene, tas inn i de økonomiske kalkyler for prosjektet så raskt som mulig slik at de kommer inn under den endelige kostnadsrammen.

Ut i fra det beste skjønn anser jeg ikke at Letsibogodammen og vannrørledningen vil få signifikante negative regionale eller lokalklimatiske konsekvenser. De eksisterende ekstreme biogeofysiske forhold i regionen gjør at de omdirigerte vannmengdene relativt sett må anses som små. Det må imidlertid understrekes at en slik vurdering er basert på generell forståelse av eksisterende forhold og ikke på spesifikk fagkompetanse.

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Appendix 1

Terms of reference (TOR) for the report mission (according to letter from NORAD on 16 November 1994).

The purpose of this exercise is to provide information to illuminate questions of immediate and wider anticipated environmental implications of the NSCWP in northern and southern Botswana.

The Norwegian specialist on environmental impact assessment should participate in the Project Appraisal Team and assess the scope of anticipated environmental consequences of the proposed project.

These would include, but not necessarily be limited to, the following tasks:

1 Immediate impacts on the areas to be inundated with water, and areas affected by road-building and pipe-laying.

2 The wider environmental impacts on the hydrological balances and processes in relation to major changes in water regimes in various habitats in the northern and southern parts of Botswana during different seasons, inclusive of impacts on downstream areas; wildlife and land-pressure issues should also be addressed.

3 Potential environmental impacts on water regimes and hydrological balances in adjacent areas and neighbouring countries.

4 Potential impacts causing climatic change.

Appendix 2

Abbreviations used in the text.

ADB	- African Development Bank
BCL	- Bamangwato Concession Limited
BITS	- Swedish Board for Investment and Technical Support
BPC	- Botswana Power Corporation
Ca	- Calcium
Cu	- Copper
DWA	- Department of Water Affairs
EIA	- Environmental Impact Assessment
EIB	- European Investment Bank
GRP	- Glass Reinforced Plastic
IUCN	- International Union for the Conservation of Nature and Natural Resoruces
K	- Potassium
LDC	- Least Developed Country
MBR	- Master Balancing Reservoir
Mg	- Magnesium
MLGL&H	- Ministry of Local Government, Lands and Housing
MMRWA	- Ministry of Mineral Resources and Water Affairs
N	- Nitrogen
NDF	- Nordic Development Fund
Ni	- Nickel
NIB	- Nordic Investment Bank
NINA	- he Norwegian Institute for Nature Research
NORAD	- Norwegian agency for development cooperation
NSC	- North-South Carrier
NSCWP	- North-South Carrier Water Project
NSCWPDC	- North-South Carrier Water Project Donors Conference
NSCWSS	- North-South Corridor Water Supply System
NWMP	- National Water Masterplan
P	- Phosphorous
PCU	- Project Coordinating Unit
PMF	- Probable Maximum Flood
SMEC	- Snowy Mountains Engineering Corporation
TOR	- Terms of Reference
WUC	- Water Utilities Corporation

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